

**BOONE & KUNKLE**

**Comparative Tests of Steam Calorimeters**

**Mechanical Engineering**

**B. S.**

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CHARLES GUTHRIE BOONE and ROY DELOS KUNKLE

ENTITLED COMPARATIVE TESTS OF STEAM CALORIMETERS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

*L. P. Brackenridge*

HEAD OF DEPARTMENT OF Mechanical Engineering



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## INTRODUCTION.

In the careful determination of the performance of a steam boiler, or a steam engine, it is essential that the quality of the steam delivered by the boiler, or to the engine, be known. This fact led to the invention of the steam calorimeter.

There has been much discussion on the subject of calorimeters themselves and also on the form and location of the sampling nipple. It was formerly assumed that, the correct sample of steam having been obtained, the throttling calorimeter would accurately determine its quality. The tests herein included, together with others, show that this is not the case.

In this thesis we shall attempt not only to set forth the information which we have obtained by our own experiments, but also to collect into one paper all reliable information which we have been able to gather from other sources. Hence we have no hesitancy in quoting such authorities as Professors R. C. Carpenter, E. H. Peabody, D. S. Jacobus and others who have made careful investigations along the line of calorimetry.



## NOTES REGARDING CALORIMETERS.

### Sampling Nipples.

The usual method of obtaining a sample of steam consists in the use of a nipple made from one-half inch pipe, perforated with one-eighth inch holes, and screwed into the side of the steam main so as to extend nearly across it; a plug is placed in the open end and care is taken in drilling the holes so that they do not come in line. The usual form of this nipple is shown in figure.

Fig. 1.

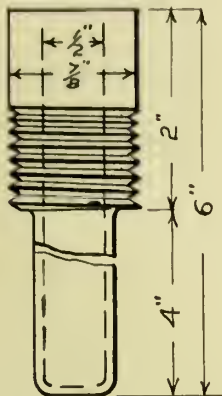


ORDINARY FORM OF SAMPLING NIPPLE.



### Thermometer Cups.

Fig. 2.



In regard to thermometer cups Prof. Carpenter says that the liquid for filling these cups is a matter of considerable importance. Both cylinder oil and mercury are satisfactory, and for most purposes there is no preference. The

mercury is perhaps the most sensitive to slight changes of temperature, but with suitable precaution cylinder oil gives satisfactory results and its cheapness makes it preferable.

### Methods of Calculating Percentage of Moisture as Indicated by Throttling Calorimeter.

There are two ways of calculating the percentage of moisture as indicated by the throttling calorimeter. One is that recommended by Mr. Barrus, and the other is by the use of the theoretical formula.

The first method is to calibrate the instrument with "dead" steam or steam obtained from a pipe open to the boiler but shut off at a point beyond the calorimeter, so that the steam in the pipe is practically in a state of rest. The reading of the lower thermometer, under these conditions, is the reading for dry steam or the "normal reading". Having determined the "normal reading" the percentage of moisture is found by dividing the difference in degrees between the normal reading and the temperature registered by the lower thermometer, by the quotient of the latent heat in B.T.U. per pound of saturated steam at the initial pres-



sure divided by (48) forty-eight.

The second method is to employ the theoretical formula which is based upon the fact that the total heat of the steam and water on the high pressure side of the orifice is equal to the total heat of the superheated steam on the low pressure side. This formula can be readily reduced to a form which, for the conditions of ordinary use, are easily tabulated or represented graphically. Thus if we represent the quality of the steam by (x), the latent heat of the steam in the main pipe by (L), the heat of the liquid by (q), the total heat of dry saturated steam due to the pressure in the calorimeter by (H), the specific heat of the steam by (c), the reading of the thermometer in calorimeter by (T), and the temperature of saturated steam at calorimeter pressure by (t), we have, supposing the expansion to occur without gain or loss of heat,

$$xL+q=H+c(T-t).$$

If the pressure in the calorimeter is atmospheric or nearly so (H) and (t) will be constant and have a value due to atmospheric pressure. In such a case the value of (X) is the equation of a straight line and may be easily plotted for different value of (T).

The method recommended by Mr. Barrus is the more convenient and reliable, because the normal reading, when properly obtained, includes all radiation effects, and corrects for any constant error there may be in the thermometer used to measure the temperature of the superheated steam on the low pressure side of the orifice; whereas, if the theoretical formula is used the ef-



fects of radiation and the error of the thermometers must be determined separately and allowed for.

## Classification and General Discussion of Error from Use of Calorimeters.

Calorimeters in general may be divided into three classes; first, those in which the moisture is determined by comparing the heat in one pound of the mixture with that of one pound of dry saturated steam; second, those in which the moisture is precipitated by mechanical means; third, those in which chemical methods are employed. In our experiments only the first two types were used.

### The Throttling Calorimeter.

The throttling calorimeter comes under the first classification, and the theory of its action as well as the method of calibrating the same are discussed above. The error due to radiation may be considerable, depending upon the radiating surface exposed and the amount of steam passing through the instrument in a given time. From the theoretical formula it may be seen that an error of nine degrees in the reading of the low temperature will cause an error of one-half per cent in the determination of the moisture.

### The Separating Calorimeter.

The separating calorimeter comes under the second classification. This calorimeter is perhaps the simplest type and is reasonably accurate. Where it fails, if it fails at all, will be in cases in which the quality of the steam is so low that



it would be condemned in any event; and a slight error in measuring the moisture in very wet steam would be of small consequence.

Let  $W$  be the weight of entrained water.

$w$ =weight of steam discharged in a given time.

$1-x$ =the amount of moisture in the steam.

Then  $1-x = \frac{W}{w+W}$ . The water glass is so graduated that the weight of water entrained may be read accurately to one one-hundredth pounds; hence the greatest error, assuming the amount of steam flowing through in the given time to be four pounds, would be less than one-fourth of one per cent.



## RESULTS OF OTHERS' TESTS.

The following are the results of tests made by Mr. Jones E. Denton, a member of the A.S.M.E. In these tests he condensed all the steam flowing in the pipe and thus determined the true percentage of moisture.

| True per cent of moisture | Moisture determined as determined by throttling calorimeter. |
|---------------------------|--------------------------------------------------------------|
| 21.0                      | 54.6                                                         |
| 17.6                      | 50.8                                                         |
| 0.5                       | 1.0                                                          |
| 2.8                       | 1.5                                                          |
| 1.0                       | 2.2                                                          |
| 1.6                       | 3.6                                                          |
| 2.5                       | 5.5                                                          |
| 19.1                      | 31.8                                                         |

Mr. Denton explains this exaggerated amount of moisture by the fact that all parts of the surface of any form of nipple, inserted in a steam main, will act as a collector for moisture, which will adhere to the metal so as to resist being detached by the comparatively swift main current of steam, but which will allow itself to be gradually drawn into the nipple by the gentler current of steam which flows into the calorimeter, because the latter has only to overcome the resistance of sliding of water



along the metal.

| <i>Number of Test.</i> | <i>Character of Nozzle.</i>                                                    | <i>Steam passing<br/>through pipe per hr.</i> | <i>Gauge Press.</i> | <i>Per cent moisture<br/>by Calorimeter</i> | <i>True Per cent<br/>Moisture.</i> |
|------------------------|--------------------------------------------------------------------------------|-----------------------------------------------|---------------------|---------------------------------------------|------------------------------------|
| <i>1.</i>              | <i>2</i>                                                                       | <i>3</i>                                      | <i>4</i>            | <i>5</i>                                    | <i>6</i>                           |
| 1.                     | <i>Vertical Nozzle with 12<br/>Holes <math>\frac{7}{32}</math>" diameter.</i>  | 1698                                          | 80                  | 5.5                                         | 2.5                                |
| 2.                     |                                                                                | 1877                                          | 80                  | 9.3                                         | 3.3                                |
| 3.                     |                                                                                | 1768                                          | 80                  | 11.1                                        | 4.7                                |
| 4.                     |                                                                                | 1788                                          | 80                  | 20.9                                        | 10.9                               |
| 5.                     |                                                                                | 2003                                          | 80                  | 31.8                                        | 19.1                               |
| 6.                     |                                                                                | 2381                                          | 80                  | 47.9                                        | 36.5                               |
| 7.                     | <i>Horizontal Nozzle with<br/>6 Holes <math>\frac{7}{32}</math>" diameter.</i> | 1538                                          | 80                  | 6.3                                         | 2.3                                |
| 8.                     |                                                                                | 1586                                          | 80                  | 8.4                                         | 3.2                                |
| 9.                     |                                                                                | 1525                                          | 80                  | 14.6                                        | 8.8                                |
| 10.                    |                                                                                | 1637                                          | 80                  | 17.8                                        | 10.1                               |
| 11.                    |                                                                                | 1745                                          | 80                  | 37.4                                        | 23.0                               |
| 12.                    |                                                                                | 2187                                          | 80                  | 46.9                                        | 37.2                               |
| 13.                    | <i>Slotted Nozzle, Slot away from cur.</i>                                     | 1577                                          | 80                  | 5.6                                         | 1.0                                |
| 14.                    | <i>" " " " toward current.</i>                                                 | 1576                                          | 80                  | 0.1                                         | 1.4                                |
| 15.                    | <i>" " " " at rt angles to "</i>                                               | 1578                                          | 80                  | 2.5                                         | 1.2                                |
| 16.                    | <i>Horizontal Nozzle with<br/>6 Holes <math>\frac{7}{32}</math>" diameter.</i> | 1810                                          | 80                  | 1.0                                         | 0.5                                |
| 17.                    |                                                                                | 1815                                          | 80                  | 1.5                                         | 0.8                                |
| 18.                    |                                                                                | 1818                                          | 80                  | 2.2                                         | 1.0                                |
| 19.                    |                                                                                | 1830                                          | 80                  | 3.6                                         | 1.6                                |

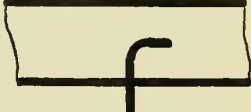
Asimilar test by Prof. D. S. Jacobus shows the following results. In this test the Prof. had two throttling calorimeters "A" and "B" a short distance apart upon the same pipe.



| No. test | Actual % moisture | Moisture shown by Cal. |     |
|----------|-------------------|------------------------|-----|
|          |                   | A                      | B   |
| 1        | 5.7               | 5.3                    | 0.7 |
| 2        | 17.2              | 39.2                   | 1.1 |
| 3        | 15.31             | 38.1                   | 1.5 |
| 4        | 15.6              | 42.8                   | 0.6 |
| 5        | 20.9              | 39.7                   | 0.5 |

Cal. "A" was located in a horizontal pipe, "B" in a vertical pipe just around an elbow from "A".

The following are the results of tests by Prof. R. C. Carpenter with an open end bent nipple arranged in such a manner that the nozzle could be turned in any direction.

| <i>True<br/>Percent<br/>Moisture</i> | <i>Percent<br/>Moisture<br/>by Cal.</i> | <i>Error</i> | <i>Position of nozzle.</i>                                                                                   |
|--------------------------------------|-----------------------------------------|--------------|--------------------------------------------------------------------------------------------------------------|
| 1.71                                 | 1.56                                    | + 0.15       | Steam from top of pipe  |
| 1.65                                 | 1.90                                    | - 0.25       | Steam from bottom.      |
| 1.52                                 | 2.25                                    | - 0.73       | Facing current.         |
| 1.53                                 | 2.57                                    | - 1.04       | Opposing current.       |
| 1.47                                 | 1.85                                    | - 0.38       | Open end nipple.        |



These trials seem to show that the difference between the quality of steam taken from the interior of the pipe and that taken from near the surface may differ by one-half per cent.

The following is a comparison of quality determinations on same sample of steam, with throttling and separating calorimeters.

| GAUGE<br>PRESS. | SEPARATING CAL.        |                              |                          |                 |                   | THROTTLING CAL. |                      |
|-----------------|------------------------|------------------------------|--------------------------|-----------------|-------------------|-----------------|----------------------|
|                 | STEAM<br>IN<br>10 MIN. | WT. OF<br>WATER<br>ENTRAINED | TOTAL<br>WT. OF<br>STEAM | $\frac{W}{W+W}$ | Radiation<br>Loss | TEMP.           | Per cent<br>Moisture |
| P               | w                      | W                            | W+w                      |                 | r                 |                 | 1-x                  |
| 76              | 4.775                  | .1718                        | 4.947                    | .0347           | .074              | 234.2           | 2.55                 |
| 77              | 4.65                   | .1406                        | 4.79                     | .02935          | .053              | 247.4           | 1.8                  |
| 81.5            | 4.85                   | .14859                       | 5.00                     | .0297           | .053              | 248.0           | 1.9                  |
| 83.0            | 4.70                   | .15062                       | 4.85                     | .03105          | .048              | 246.0           | 2.10                 |

From the results of these tests it is evident that the quality of steam as determined by Calorimeters depends largely upon the form and location of sampling nipple, style of instrument used, and even varies with different calorimeters of the same kind.

#### TESTS MADE BY THE AUTHORS.

##### Preliminary Remarks.

These tests were made in the M.E. Laboratory at the University of Illinois by Messrs. C.G. Boone and R.D. Kunkle. The general location of apparatus with respect to the steam main is shown in photograph page 46. Although other experiments show that a horizontal pipe is not the best place to obtain a fair sample of steam, we nevertheless chose a horizontal pipe on account of the convenience of this particular location, and moreover our tests, being merely comparative, did not require a true



sample of the steam in the main.

This position was particularly convenient since, being just beyond a separator, we had no fear that the steam would ever become too wet to be measured with throttling calorimeters. The valve in the steam main, near the separator, enabled us to shut off the steam at any time in order to change the sampling nipple.

The forms of Calorimeters tested were Carpenter's Separating, Carpenter's Throttling, 1905 Pattern Universal Throttling, and a Throttling calorimeter which we made from pipe fittings.

#### DESCRIPTION OF APPARATUS.

##### Carpenter's Separating Cal.

The construction of the Carpenter's separating calorimeter is shown in sketch No.(8) page (50). Its action is a simple mechanical separation of the moisture from the steam.

The instrument consists of two vessels, one being interior to the other; the outer vessel surrounds the inner one so as to leave a space which acts as a steam jacket. The interior vessel is provided with a water-gauge glass (10) and a graduated scale (12). The sample of steam whose quality is to be determined is supplied through the pipe (6) into the upper portion of the interior vessel. The water in the steam is thrown downward into the cup (14), together with more or less of the steam; the course of the steam and water is then changed through an angle of nearly one hundred and eighty degrees which causes the entire amount of water to be thrown outward through the meshes of the cup into the space (3), which constitutes the inner chamber. The cup serves to keep the current of steam from taking up any moisture which has



already been thrown out by the force of inertia. The ~~reses~~ project upward into the inside of the cup, so that any water intercepted will drip into the chamber (3). The steam then passes upward, and enters the top of the outside chamber. It is discharged from the bottom of the outside chamber through an orifice (8) of known area, which is much smaller in section than any of the passages through the calorimeter, so that the steam in the outer chamber suffers no sensible reduction in pressure. The pressure in the outside chamber, being the same as that in the inner chamber has the same temperature, and consequently no loss of radiation can take place from the interior chamber except that which takes place from the exposed surface of the gauge glass and fittings. The pressure in the outer chamber, and also the flow of steam in a given time is shown by suitable scales on the attached gauge. The scale for showing the flow of steam gives the discharge of steam in pounds in ten minutes of time. The readings on the scale (12) show the weight of water in the interior vessel (3), and should be taken at the beginning and end of the interval.

#### Carpenter's Throttling Calorimeter.

The construction of Carpenter's throttling calorimeter is shown in fig. (7 ). Its action consists in the simple throttling of the steam through a small orifice. The steam enters through the small orifice and in so doing is throttled down to almost atmospheric pressure. The amount of superheat is determined by the thermometer (T) inserted in the cup (C). The theory of its action and the method of calculating the per cent of moisture from its readings is explained on page (4 ).



Calorimeter made from Pipe Fittings.

Fig. ( 5 ) shows the construction of the calorimeter which we made from three-quarter ( $\frac{3}{4}$ ) inch pipe fittings.

Between the two flanges of the union "A" is bolted a circular steel disc  $\frac{1}{8}$ " in thickness. In the center of this disc is a  $\frac{3}{32}$ " orifice through which the steam is throttled. This plate is insulated from the flanges on both sides by means of asbestos packing. The thermometer cups "T" are made of brass according to dimensions on sketch page ( 3 ). They are screwed into  $\frac{1}{2}$ " bushings which are in turn screwed into the  $\frac{3}{4}$ " tees. At "B" is a  $\frac{1}{4}$ " pet cock for draining the water from the calorimeter. The small pipe at "C" serves as a connection for a manometer tube. The calorimeter is connected to the steam main at "D" and steam escapes at "E".

#### CALIBRATION OF INSTRUMENTS.

##### Gauges.

All gauges were calibrated by the use of the Crosby steam-gauge Testing Apparatus.

##### Calorimeters.

The throttling calorimeters were calibrated by the use of "Dead Steam" as explained in "Notes regarding Calorimeters" page 3 . This method is recommended by Mr. Barrus who has done no little experimenting with throttling calorimeters. In order to satisfy ourselves that the calibration was correct, we took numerous "normal readings" at different pressures at different times, all of which agreed very closely.

By the use of this calibration in the calculation of



per cent moisture in the steam, we avoided the necessity of calibrating our thermometers each of which was always used in the same thermometer cup.

#### METHODS OF CONDUCTING TESTS.

The photograph on page 46 shows the general method employed in connecting our apparatus to the steam main. In all tests all instruments and connections were carefully wrapped with one inch thickness of hair felt. This provision was made in order that loss of heat by radiation be reduced to a minimum.

The steam main shown is a six inch pipe direct from boiler room, about seventy-five feet distant, and was covered with ordinary magnesia pipe covering. The amount of steam flowing in main varied at different times, depending upon the number of engines and other machines running in the laboratory. The pressure varied from one hundred (100) to one hundred and thirty (130) pounds, gauge, during the tests.

The nipples at A and B were located about thirty inches apart. Between them, connected to the main, was a Crosby Steam-gauge.

Previous to each test, the steam was allowed to flow through the calorimeters for ten or fifteen minutes in order to thoroughly heat up the instruments and connections. Each test extended over a period of from twenty to thirty minutes. Readings were taken every five minutes. The liquid used in the thermometer cups was cylinder oil. In preliminary tests there had been noticed, in the thermometers, a slight tendency to lag during changes of pressure in the steam main. By extending the test over



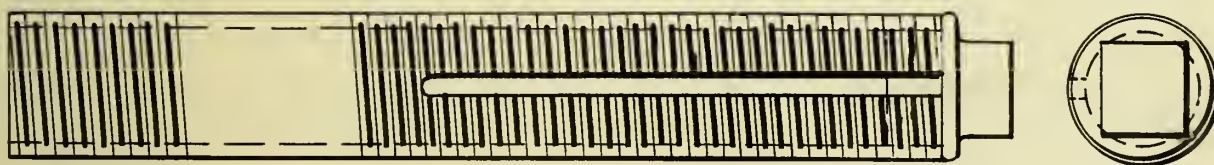
a period of twenty or thirty minutes, the error due to the lag in thermometer was made a compensating one since the pressure would both rise and fall in that length of time.

In the first tests, the ordinary form of perforated nipple, shown on page (2) of this thesis, was used at both (A) and (B). A "tee" was screwed on the nipple at (A) which insured the same quality of steam passing through the two calorimeters connected thereon. Several tests were run with every combination of the four calorimeters placed three at a time upon the two nipples.

The "tee" was then placed on nipple at (B) and the same process repeated.

The nipple at (B) was then replaced by a slotted nipple shown in fig. (3).

Fig. 3.



SLOTTED NIPPLE.

The slot was turned in several positions with respect to the direction of the current of steam in the main. The results of this test are shown on page (25). Tests were made upon this nipple with both separating and throttling calorimeters.



The simple open-end nipple shown in figure below was then substituted for slotted one.

Fig. 4.



OPEN-END NIPPLE.

This nipple was of such a length as to reach about to the center of the steam main, thus taking the sample from the middle of the current only.

The results of these tests are shown both in tabular and graphical form in the following pages.

In the following results, the per cent of moisture was calculated by obtaining the mean readings of each test and then employing the calibration curves shown on page 43, and explained on page 3 .

#1

In all the tests calorimeter<sup>^</sup> refers to the one made of pipe fittings, #2, to the 1905 Pattern Universal; #3 to the Carpenter Throttling, and #4 the Separating Calorimeter. When the form of nipple is not indicated the ordinary perforated nipple was used.



# LOG OF DATA OF ALL TESTS

OBSERVERS IN ALL TESTS, MESSRS. BOONE & KUNKLE.

## TEST #1.

| TIME  | GAUGE | CAL. #1. | MAN.<br>INS.<br>HG. | CAL. #2 | CAL. #4. |                        |                        |
|-------|-------|----------|---------------------|---------|----------|------------------------|------------------------|
|       |       | TEMP.    |                     | TEMP.   | TIME     | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 10:40 | 117   | 258      | .6                  | 284     | 10:35    | 3.085                  | .153                   |
| 10:50 | 116   | 261.8    | .6                  | 281.9   | 10:45    | 3.11                   | .175                   |
| 11:00 | 115   | 263.0    | .6                  | 282.0   | 11:05    | 3.08                   | .202                   |
| 11:10 | 116   | 260.     | .6                  | 284.5   | 11:15    | 3.15                   | .202                   |
| 11:20 | 114   | 260.5    | .6                  | 285.2   | 11:25    | 2.92                   | .226                   |
| 11:30 | 115   | 259.     | .6                  | 282.    | 11:35    | 3.02                   | .249                   |
| 11:40 | 119   | 262.     | .6                  | 286.    | 11:45    | 3.23                   | .260                   |

1 & 2 on same nipple 4 on other.

Per Cent moisture by #1 = 0.945

" " " " #2 = -0.15

" " " " #4 = 0.60

## TEST #2

| TIME | GAGE | CAL. #1 | MAN.<br>INS.<br>HG. | CAL. #2 | CAL. #4. |                        |                        |
|------|------|---------|---------------------|---------|----------|------------------------|------------------------|
|      |      | TEMP.   |                     | TEMP.   | TIME     | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 1:30 | 116  | 257     | .6                  | 278     | 1:32     | 3.21                   | .05                    |
| 1:35 | 117  | 254     | .6                  | 279     | 1:42     | 3.08                   | .093                   |
| 1:40 | 118  | 256     | .6                  | 277     | 1:52     | 3.15                   | .115                   |
| 1:45 | 123  | 255     | .6                  | 281     |          |                        |                        |
| 1:50 | 119  | 255     | .6                  | 280     |          |                        |                        |

1 & 4 on same nipple, 2 on other.

Per Cent moisture by 1 = 1.26.

" " " " 2 = 0.00.

" " " " 4 = 1.03.



## TEST #3

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 |      | CAL. 4.                |                        |
|------|-------|--------|--------------------|--------|------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TIME | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 2:20 | 119   | 254    | .6                 | 277    | 2:22 | 3.00                   | .045                   |
| 2:25 | 120   | 254    | .6                 | 275    |      |                        |                        |
| 2:30 | 121   | 251    | .6                 | 278    | 2:32 | 3.11                   | .109                   |
| 2:35 | 117   | 249    | .6                 | 280    |      |                        |                        |
| 2:40 | 117   | 250    | .6                 | 283    | 2:42 | 3.12                   | .161                   |

2 & 4 on same nipple, 1 on other.

Per cent moisture by 1 = 1.43.

" " " " 2 = 0.00.

" " " " 4 = 1.89.

## TEST #4.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 |      | CAL. 4.                |                        |
|------|-------|--------|--------------------|--------|------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TIME | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 2:53 | 110   | 250    | .5                 | 272    | 2:50 | 2.97                   | .025                   |
| 2:58 | 98    | 252    | .5                 | 222    |      |                        |                        |
| 3:03 | 107   | 248    | .5                 | 218    | 3:00 | 2.47                   | .26                    |
| 3:08 | 106   | 244    | .5                 | 221    |      |                        |                        |
| 3:13 | 121   | 244    | .5                 | 212    | 3:10 | 2.86                   | .62                    |
| 3:18 | 130   | 242    | .5                 | 211    |      |                        |                        |
| 3:23 | 128   | 246    | .5                 | 211.5  | 3:20 | 3.35                   | 1.07                   |
| 3:28 | 128   | 250    | .5                 | 211.5  |      |                        |                        |
| 3:33 | 133   | 247    | .5                 | 211    | 3:30 | 3.40                   | .05                    |
| 3:38 | 132   | 247    | .5                 | 211    |      |                        |                        |
| 3:43 | 131   | 248    | .5                 | 211.5  | 3:40 | 3.22                   | .52                    |
| 3:48 | 121   | 249    | .5                 | 212    |      |                        |                        |

1 & 2 on same nipple, 4 on other.

Per cent moisture by 1 = 1.705

" " " " 2 = 2.88

" " " " 4 = 1.90



## TEST # 5

| TIME | GAUGE | CAL. 1. |                    | CAL. 3 |      | CAL. 4.                 |                         |
|------|-------|---------|--------------------|--------|------|-------------------------|-------------------------|
|      |       | TEMP.   | MAN.<br>17.<br>HG. | TEMP.  | TIME | STEAM<br>17.<br>10 MIN. | WATER<br>17.<br>10 MIN. |
| 3:07 | 108.5 | 264     | .8                 | 218    | 3:10 | 3.01                    | .013                    |
| 3:12 | 116   | 274     | .8                 | 234    |      |                         |                         |
| 3:17 | 114   | 280     | .8                 | 245    | 3:20 | 3.04                    | .071                    |
| 3:22 | 109.5 | 281     | .8                 | 251    |      |                         |                         |
| 3:27 | 107   | 281.5   | .8                 | 251    | 3:30 | 2.91                    | .107                    |
| 3:32 | 108.5 | 278     | .8                 | 240    |      |                         |                         |
| 3:37 | 110   | 277.5   | .7                 | 242    | 3:40 | 2.92                    | .149                    |
| 3:42 | 105   | 279     | .7                 | 249    |      |                         |                         |
| 3:47 | 109   | 276     | .7                 | 234    | 3:50 | 2.95                    | .186                    |
| 3:52 | 114   | 276     | .7                 | 236    |      |                         |                         |
| 3:57 | 113   | 278     | .65                | 249    | 4:00 | 2.97                    | .216                    |
| 4:02 | 108   | 281     | .65                | 260    |      |                         |                         |

1 & 3 on same nipple, 4 on other.  
Per cent moisture by 1 = .152

" " " " 3 = 1.92

" " " " 4 = 1.27

## TEST # 6.

| TIME | GAUGE | CAL. 1 |                    | CAL. 3 |      | CAL. 4.                 |                         |
|------|-------|--------|--------------------|--------|------|-------------------------|-------------------------|
|      |       | TEMP.  | MAN.<br>17.<br>HG. | TEMP.  | TIME | STEAM<br>17.<br>10 MIN. | WATER<br>17.<br>10 MIN. |
| 2:28 | 109   | 264    | .8                 | 245    | 2:30 | 3.00                    | .21                     |
| 2:33 | 112   | 271    | .8                 | 245    |      |                         |                         |
| 2:38 | 114   | 280    | .8                 | 253    | 2:40 | 3.04                    | .70                     |
| 2:43 | 120   | 283    | .8                 | 257    |      |                         |                         |
| 2:48 | 117   | 278    | .8                 | 254    | 2:50 | 2.90                    | 1.23                    |
| 2:53 | 121   | 270    | .8                 | 260    |      |                         |                         |

3 & 4 on same nipple, 1 on other

Per cent moisture by 1 = .276

" " " " 3 = 1.36

" " " " 4 = 1.68



## TEST #7

| TIME | GAUGE | CAL. 1. |                   | CAL. 3 | CAL. 4. |                        |                        |
|------|-------|---------|-------------------|--------|---------|------------------------|------------------------|
|      |       | TEMP    | MAN.<br>in<br>Hg. | TEMP   | TIME    | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 4:32 | 105   | 216     | .8                | 256    | 4:30    | 2.80                   | .028                   |
| 4:37 | 108   | 220     | .8                | 240    |         |                        |                        |
| 4:42 | 113   | 222     | .8                | 240    | 4:40    | 2.82                   | .046                   |
| 4:47 | 120   | 223     | .8                | 230    |         |                        |                        |
| 4:52 | 114   | 227     | .8                | 235    | 4:50    | 3.21                   | .069                   |
| 4:57 | 105   | 232     | .8                | 233    |         |                        |                        |
| 5:02 | 102   | 230     | .8                | 229    | 5:00    | 2.81                   | .082                   |
| 5:07 | 111   | 228     | .8                | 218    |         |                        |                        |
| 5:12 | 115.5 | 228     | .8                | 222    | 5:10    | 3.03                   | .101                   |
| 5:17 | 117   | 230     | .8                | 230    |         |                        |                        |
| 5:22 | 110   | 235     | .8                | 274    | 5:20    | 3.10                   | .122                   |
| 5:27 | 97.5  | 238     | .8                | 269    |         |                        |                        |

1 & 3 on same nipple, 4 on other.

Per cent moisture by 1 = 2.50

" " " " 3 = 1.97

" " " " 4 = 0.60.

## TEST #8.

| TIME | GAUGE | CAL. 1 |                   | CAL. 3 | CAL. 4. |                        |                        |
|------|-------|--------|-------------------|--------|---------|------------------------|------------------------|
|      |       | TEMP   | MAN.<br>in<br>Hg. | TEMP   | TIME    | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 1:57 | 107   | 271    | .7                | 226    | 2:00    | 2.87                   | -0.050                 |
| 2:02 | 109   | 269    | .7                | 221    |         |                        |                        |
| 2:07 | 114   | 269    | .7                | 220    | 2:10    | 3.05                   | 0.10                   |
| 2:12 | 112   | 272    | .7                | 229    |         |                        |                        |
| 2:17 | 110   | 273    | .7                | 229    | 2:20    | 2.87                   | 0.25                   |
| 2:22 | 103   | 273    | .7                | 232    |         |                        |                        |
| 2:27 | 100   | 272    | .7                | 230    | 2:30    | 2.77                   | 0.37                   |
| 2:32 | 106.5 | 267    | .7                | 220    |         |                        |                        |
| 2:37 | 114   | 268    | .7                | 219    | 2:40    | 3.00                   | 0.50                   |
| 2:42 | 113   | 271    | .7                | 229    |         |                        |                        |

3 & 4 on same nipple, 1 on other.

Per cent moisture by 1 = .376

" " " " 3 = 2.19

" " " " 4 = .500



## TEST #9

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 3. |
|------|-------|--------|--------------------|--------|---------|
|      |       | TEMP   | MAN.<br>in.<br>HG. | TEMP   | TEMP    |
| 3:30 | 109   | 264    | .4                 | 221    | 255     |
| 3:35 | 113   | 265    | .4                 | 212    | 250     |
| 3:40 | 111   | 264    | .4                 | 212    | 254     |
| 3:45 | 114   | 264    | .4                 | 212    | 250     |
| 3:50 | 123   | 259    | .4                 | 212    | 239     |
| 3:50 | 117   | 268    | .4                 | 241    | 247     |
| 3:55 | 121   | 271    | .4                 | 232    | 243     |

2 & 3 on same nipple, 1 on other.

Per cent moisture by 1 = .76

" " " " 2 = 2.76

" " " " 3 = 1.6.

## TEST #10.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 4. |                        |                        |
|------|-------|--------|--------------------|--------|---------|------------------------|------------------------|
|      |       | TEMP   | MAN.<br>in.<br>HG. | TEMP   | TIME    | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 2:25 | 114   | 275    | .6                 | 250    | 2:27    | 3.04                   | 0.00                   |
| 2:30 | 113   | 273    | .6                 | 251    |         |                        |                        |
| 2:35 | 117   | 276    | .6                 | 254    | 2:37    | 3.00                   | .032                   |
| 2:40 | 117   | 277    | .6                 | 253    |         |                        |                        |
| 2:45 | 120   | 276    | .6                 | 253    | 2:47    | 3.18                   | .060                   |

1 & 4 on same nipple, 2 on other.

per cent moisture by 1 = .247

" " " " 2 = 1.21

" " " " 4 = .97



## TEST #11

| TIME | GAUGE | CAL. 2 | CAL. 3             |       | CAL. 4. |                        |                        |
|------|-------|--------|--------------------|-------|---------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP. | TIME    | STEAM<br>IN<br>10 MIN. | WATER<br>IN<br>10 MIN. |
| 3:15 | 113   | 260    | .6                 | 270   | 3:12    | 3.00                   | .050                   |
| 3:20 | 119   | 261    | .6                 | 271   |         |                        |                        |
| 3:25 | 119   | 261    | .6                 | 269   | 3:22    | 3.18                   | .073                   |
| 3:30 | 123   | 259    | .6                 | 273   |         |                        |                        |
| 3:35 | 124   | 267    | .6                 | 274   | 3:32    | 3.23                   | .097                   |

269 on same nipple, 3 on other.

Per cent moisture by 2 = .845

" " " " 3 = .570

" " " " 4 = .780

## TEST #12

| TIME | GAUGE | CAL. 2 | CAL. 3             |       | CAL. 4. |                        |                        |
|------|-------|--------|--------------------|-------|---------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP. | TIME    | STEAM<br>IN<br>10 MIN. | WATER<br>IN<br>10 MIN. |
| 4:15 | 112   | 265    | .6                 | 274   | 4:17    | 3.00                   | .023                   |
| 4:20 | 113   | 266    | .6                 | 273   |         |                        |                        |
| 4:25 | 114   | 260    | .6                 | 270   | 4:27    | 2.87                   | .047                   |
| 4:30 | 107   | 261    | .6                 | 271   |         |                        |                        |
| 4:35 | 111   | 267    | .6                 | 272   | 4:37    | 2.94                   | .076                   |

364 on same nipple, 2 on other.

Per cent moisture by 2 = .56

" " " " 3 = .316

" " " " 4 = .89



## TEST #13

| TIME | GAUGE | CAL. 1 |                    | CAL. 2. | CAL. 3. |
|------|-------|--------|--------------------|---------|---------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.   | TEMP.   |
| 2:45 | 115   | 269    | .6                 | 276     | 243     |
| 2:50 | 109   | 266    | .6                 | 275     | 238     |
| 2:55 | 109   | 265    | .6                 | 274     | 237     |
| 3:00 | 112   | 263    | .6                 | 274     | 236     |
| 3:05 | 115   | 263    | .6                 | 276     | 237     |
| 3:10 | 113   | 266    | .6                 | 277     | 238     |
| 3:15 | 112   | 265    | .6                 | 276     | 237     |
| 3:20 | 111   | 265    | .6                 | 275     | 236     |

263 on East nipple, 1 on West.

Per cent moisture by 1 = .698.

" " " " 2 = .167.

" " " " 3 = 1.94.

## TEST #14.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2. | CAL. 3. |
|------|-------|--------|--------------------|---------|---------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.   | TEMP.   |
| 4:20 | 120   | 245    | .6                 | 277     | 276     |
| 4:25 | 125   | 246    | .6                 | 279     | 277     |
| 4:30 | 111   | 259    | .6                 | 282     | 282     |
| 4:35 | 105   | 260    | .6                 | 280     | 280     |
| 4:40 | 107   | 256    | .6                 | 279     | 278     |
| 4:45 | 114   | 251    | .6                 | 280     | 279     |
| 4:50 | 112   | 246    | .6                 | 282     | 280     |
| 4:55 | 106   | 259    | .6                 | 282     | 280     |

263 on West nipple, 1 on East.

Per cent moisture by 1 = 1.34

" " " " 2 = .02

" " " " 3 = .11



## TEST #15.

| TIME | GAUGE | CAL. 1. |                    | CAL. 2 | C.F.L. 4. |                        |                        |
|------|-------|---------|--------------------|--------|-----------|------------------------|------------------------|
|      |       | TEMP.   | MAN.<br>in.<br>HG. | TEMP.  | TIME      | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 2:37 | 114   | 214     | .7                 | 213    | 2:40      | 3.04                   | -.004                  |
| 2:42 | 114   | 217     | .7                 | 219    |           |                        |                        |
| 2:47 | 113   | 218     | .7                 | 218    | 2:50      | 3.00                   | .028                   |
| 2:52 | 116   | 217     | .7                 | 217    |           |                        |                        |
| 2:57 | 118   | 217.5   | .7                 | 217    | 3:00      | 3.13                   | .050                   |
| 3:02 | 119   | 223     | .7                 | 240    |           |                        |                        |
| 3:07 | 120   | 214     | .7                 | 218    | 3:10      | 3.20                   | .072                   |
| 3:12 | 121   | 214     | .7                 | 219    |           |                        |                        |
| 3:17 | 122.5 | 214     | .7                 | 219    | 3:20      | 3.23                   | .094                   |

2 & 4 on same nipple, 1 on other.

Per cent moisture by 1 = 3.19

" " " " 2 = 3.10

" " " " 4 = .94

## TEST #16

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | C.F.L. 4. |                        |                        |
|------|-------|--------|--------------------|--------|-----------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TIME      | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 4:07 | 127.5 | 264    | .7                 | 264    | 4:10      | 3.40                   | .022                   |
| 4:12 | 122   | 266    | .7                 | 276    | 4:15      | 3.22                   | .171                   |
| 4:17 | 121   | 266    | .7                 | 278    | 4:20      | 3.13                   | .060                   |
| 4:22 | 121   | 267    | .7                 | 280    | 4:25      | 3.13                   | .180                   |
| 4:27 | 120   | 268    | .7                 | 281    |           |                        |                        |
| 4:32 | 119   | 273    | .7                 | 280    | 4:35      | 3.08                   | .050                   |
| 4:37 | 117   | 274    | .7                 | 279    |           |                        |                        |
| 4:42 | 114   | 272    | .7                 | 278    | 4:40      | 2.99                   | .103                   |
| 4:47 | 112   | 272    | .7                 | 276    |           |                        |                        |

1 & 2 on same nipple, 4 on other.

Per cent moisture by 1 = .558

" " " " 2 = -.148

" " " " 4 = 4.7



## TEST #17.

|      |       | CAL. 1 |                    | CAL. 2 | CAL. 4. |                        |                        |
|------|-------|--------|--------------------|--------|---------|------------------------|------------------------|
| TIME | GAUGE | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TIME    | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 3:00 | 116   | 277    | .5                 | 270    | 2:52    | 3.08                   | -.001                  |
| 3:05 | 115   | 279    | .5                 | 270    |         |                        |                        |
| 3:10 | 112   | 278    | .5                 | 276    | 3:02    | 2.98                   | .061                   |
| 3:15 | 116   | 280    | .5                 | 279    | 3:12    | 3.08                   | .150                   |

1 & 2 on same nipple, 4 on slotted nipple. (slot down)

Per cent moisture by 1 = .057

" " " " 2 = .070

" " " " 4 = 2.42

## TEST #18.

|      |       | CAL. 1. |                    | CAL. 2 | CAL. 4. |                        |                        |
|------|-------|---------|--------------------|--------|---------|------------------------|------------------------|
| TIME | GAUGE | TEMP.   | MAN.<br>in.<br>HG. | TEMP.  | TIME    | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 3:20 | 120   | 278     | .5                 | 276    | 3:19    | 3.19                   | .038                   |
| 3:25 | 120   | 282     | .5                 | 281    |         |                        |                        |
| 3:30 | 120   | 281     | .5                 | 281    | 3:29    | 3.19                   | .078                   |
| 3:35 | 118   | 280     | .5                 | 281    |         |                        |                        |
| 3:40 | 115   | 279     | .5                 | 280    | 3:39    | 3.07                   | .111                   |

1 & 2 on same nipple, 4 on slotted nipple (slot away)

Per cent moisture by 1 = .054.

" " " " 2 = -.105.

" " " " 4 = 1.16.



## TEST # 19.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 4 |                        |                        |
|------|-------|--------|--------------------|--------|--------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.  | TIME   | STEAM<br>IN<br>10 MIN. | WATER<br>IN<br>10 MIN. |
| 3:50 | 118   | 274    | .6                 | 276    | 3:48   | 3.12                   | .018                   |
| 3:55 | 121   | 277    | .6                 | 280    |        |                        |                        |
| 4:00 | 125   | 280    | .6                 | 282    | 3:58   | 3.29                   | .080                   |
| 4:05 | 127   | 280    | .6                 | 284    |        |                        |                        |
| 4:10 | 128   | 278    | .6                 | 281    | 4:08   | 3.33                   | .145                   |

1 & 2 on same nipple, 4 on slotted nipple. (slot toward current.)

Per cent moisture by 1 = .069

" " " " 2 = .104.

" " " " 4 = 1.98

## TEST # 20.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 4 |                        |                        |
|------|-------|--------|--------------------|--------|--------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.  | TIME   | STEAM<br>IN<br>10 MIN. | WATER<br>IN<br>10 MIN. |
| 4:27 | 110   | 269    | .6                 | 271    | 4:25   | 2.93                   | .031                   |
| 4:32 | 114   | 276    | .6                 | 279    |        |                        |                        |
| 4:37 | 117   | 278    | .6                 | 281    | 4:38   | 3.10                   | .069                   |
| 4:42 | 114   | 278    | .6                 | 281    |        |                        |                        |
| 4:47 | 111   | 278    | .6                 | 279    | 4:45   | 2.97                   | .112                   |

1 & 2 on same nipple, 4 on slotted nipple. (slot up).

Per cent moisture by 1 = .081

" " " " 2 = .005

" " " " 4 = 1.37



## TEST #21.

| TIME | GAUGE | CAL. 1 |                    | CAL. 3 | TIME | CAL. 4.                |                        |
|------|-------|--------|--------------------|--------|------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  |      | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 2:30 | 109   | 237    | .7                 | 244    | 2:32 | 2.90                   | .003                   |
| 2:35 | 111   | 242    | .7                 | 251    |      |                        |                        |
| 2:40 | 115   | 243    | .7                 | 255    | 2:42 | 3.05                   | .037                   |
| 2:45 | 112   | 241    | .7                 | 250    |      |                        |                        |
| 2:50 | 112   | 250    | .7                 | 255    | 2:52 | 2.98                   | .102                   |

1 & 4 on same nipple, 3 on other.

Per cent moisture by 1 = 1.77.

" " " " 3 = 1.36.

" " " " 4 = 1.64.

## TEST #22.

| TIME | GAUGE | CAL. 1 |                    | CAL. 3 | TIME | CAL. 4.                |                        |
|------|-------|--------|--------------------|--------|------|------------------------|------------------------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  |      | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 3:20 | 110   | 265    | .7                 | 233    | 3:22 | 2.93                   | .010                   |
| 3:25 | 112   | 270    | .7                 | 240    |      |                        |                        |
| 3:30 | 117   | 267    | .7                 | 237    | 3:32 | 3.10                   | .085                   |
| 3:35 | 115   | 273    | .7                 | 250    |      |                        |                        |
| 3:40 | 113   | 270    | .7                 | 257    | 3:42 | 3.00                   | .160                   |

3 & 4 on same nipple, 1 on other.

Per cent moisture by 1 = .50.

" " " " 3 = 1.75.

" " " " 4 = 6.90.



## TEST # 23.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 3. |
|------|-------|--------|--------------------|--------|---------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.  | TEMP.   |
| 2:30 | 114   | 220    | .7                 | 235    | 240     |
| 2:35 | 113   | 223    | .7                 | 232    | 230     |
| 2:40 | 112   | 230    | .7                 | 227    | 237     |
| 2:45 | 118   | 227    | .7                 | 240    | 240     |
| 2:50 | 118   | 235    | .7                 | 245    | 252     |

1 & 3 on same nipple, 2 on other.

Per cent moisture by 1 = 2.57.

" " " " 2 = 1.81.

" " " " 3 = 2.14.

## TEST # 24.

| TIME | GAUGE | CAL. 2 |                    | CAL. 3 |      | CAL. 4.                 |                         |
|------|-------|--------|--------------------|--------|------|-------------------------|-------------------------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.  | TIME | STEAM<br>IN.<br>10 MIN. | WATER<br>IN.<br>10 MIN. |
| 3:20 | 119   | 240    | .7                 | 250    | 3:22 | 3.16                    | .012                    |
| 3:25 | 113   | 243    | .7                 | 263    |      |                         |                         |
| 3:30 | 115   | 256    | .7                 | 257    | 3:32 | 3.05                    | .053                    |
| 3:35 | 112   | 247    | .7                 | 257    |      |                         |                         |
| 3:40 | 112.5 | 243    | .7                 | 261    | 3:42 | 3.00                    | .099                    |

2 & 4 on same nipple, 3 on other.

Per cent moisture by 2 = 1.55

" " " " 3 = 1.13

" " " " 4 = 1.46



## TEST #25.

| TIME | GAUGE | CAL. 1             |       | CAL. 2. |
|------|-------|--------------------|-------|---------|
|      |       | MAN.<br>IN.<br>HG. | TEMP. | TEMP.   |
| 1:42 | 112   | .6                 | 270   | 273     |
| 1:47 | 113   | .6                 | 270   | 273     |
| 1:52 | 114   | .6                 | 269   | 276     |
| 1:57 | 115   | .6                 | 267   | 276     |
| 2:02 | 115   | .6                 | 269   | 276     |

1 & 2 on same nipple.

per cent moisture by 1 = .471

" " " " 2 = .263

## TEST # 26

| TIME | GADGE | MAN.<br>IN.<br>HG. | CAL. 1. | CAL. 2. |
|------|-------|--------------------|---------|---------|
|      |       |                    | TEMP.   | TEMP.   |
| 2:15 | 105   | .6                 | 259     | 248     |
| 2:20 | 104   | .6                 | 241     | 250     |
| 2:25 | 104   | .6                 | 258     | 254     |
| 2:30 | 106   | .6                 | 266     | 258     |
| 2:35 | 106   | .6                 | 256     | 253     |

1 & 2 on same nipple,

per cent moisture by 1 = 1.17.

" " " " 2 = 1.09.



## TEST 27

| TIME | GAUGE | CAL. 1. |                    | CAL. 2 | CAL. 3 |
|------|-------|---------|--------------------|--------|--------|
|      |       | TEMP.   | MAN.<br>in.<br>HG. | TEMP.  | TEMP.  |
| 3:45 | 105   | 271     | .5                 | 237    | 275    |
| 3:50 | 105.5 | 272     | .5                 | 240    | 275    |
| 3:55 | 107   | 272     | .5                 | 245    | 275    |
| 4:00 | 107.5 | 273     | .5                 | 247    | 274    |
| 4:05 | 106   | 272     | .5                 | 243    | 274    |

1 & 2 on same nipple, 3 on slotted nipple, (slot down).

Per cent moisture by 1 = .214

" " " " 2 = 1.48

" " " " 3 = .071

## TEST # 28

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 3 |
|------|-------|--------|--------------------|--------|--------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TEMP.  |
| 4:15 | 107   | 274    | .5                 | 255    | 271    |
| 4:20 | 106   | 272    | .5                 | 255    | 270    |
| 4:25 | 105   | 273    | .5                 | 256    | 268    |
| 4:30 | 105   | 273    | .5                 | 256    | 268    |
| 4:35 | 106   | 273    | .5                 | 256    | 269    |

1 & 2 on same nipple, 3 on slotted nipple. (slot away)

Per cent moisture by 1 = .20

" " " " 2 = .753

" " " " 3 = .30



# TEST #29

|      |       | CAL. 1 |                    | CAL. 2 | CAL. 3 |
|------|-------|--------|--------------------|--------|--------|
| TIME | GAUGE | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TEMP.  |
| 4:45 | 107   | 274    | .5                 | 256    | 266    |
| 4:50 | 108   | 272    | .5                 | 258    | 271    |
| 4:55 | 107   | 273    | .5                 | 258    | 272    |
| 5:00 | 104   | 273    | .5                 | 258    | 273    |
| 5:05 | 106   | 273    | .5                 | 257    | 271    |

1 & 2 on same nipple, 3 on slotted nipple, (slot up).

Per cent moisture by 1 = .90  
 " " " " 2 = .753  
 " " " " 3 = .955

# TEST #30

|      |       | CAL. 1 |                    | CAL. 2 | CAL. 3. |
|------|-------|--------|--------------------|--------|---------|
| TIME | GAUGE | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TEMP.   |
| 5:15 | 107   | 272    | .5                 | 257    | 273     |
| 5:20 | 107   | 272    | .5                 | 257    | 273     |
| 5:25 | 111   | 271    | .5                 | 257    | 273     |
| 5:30 | 115   | 272    | .5                 | 259    | 274     |
| 5:35 | 110   | 272    | .5                 | 259    | 273     |

1 & 2 on same nipple, 3 on slotted nipple, (slot toward current).

Per cent moisture by 1 = .90  
 " " " " 2 = .729  
 " " " " 3 = .24



## TEST # 31.

|      |       | CAL. 1 |                    | CAL. 3 | CAL. 4. |                        |                        |
|------|-------|--------|--------------------|--------|---------|------------------------|------------------------|
| TIME | GAUGE | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TIME    | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 1:30 | 114   | 271    | .6                 | 264    | 1:32    | 3.05                   | .018                   |
| 1:35 | 115   | 272    | .6                 | 265    |         |                        |                        |
| 1:40 | 115   | 272    | .6                 | 260    | 1:42    | 3.03                   | .064                   |
| 1:45 | 113   | 268    | .6                 | 261    |         |                        |                        |
| 1:50 | 115   | 275    | .6                 | 263    | 1:52    | 3.05                   | .103                   |

1 & 4 on same nipple, 3 on other.

Per cent moisture by 1 = .68

" " " " 3 = 1.09

" " " " 4 = 2.72

## TEST # 32

|      |       | CAL. 1 |                    | CAL. 3 | CAL. 4. |                        |                        |
|------|-------|--------|--------------------|--------|---------|------------------------|------------------------|
| TIME | GAUGE | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TIME    | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 2:20 | 119   | 276    | .6                 | 243    | 2:23    | 3.12                   | .175                   |
| 2:25 | 118   | 277    | .6                 | 241    |         |                        |                        |
| 2:30 | 119   | 280    | .6                 | 245    | 2:33    | 3.20                   | .208                   |
| 2:35 | 121   | 274    | .6                 | 250    |         |                        |                        |
| 2:40 | 120   | 273    | .6                 | 252    | 2:43    | 3.20                   | .251                   |

3 & 4 on same nipple, 2 on other.

Per cent moisture by 2 = .271.

" " " " 3 = 1.57.

" " " " 4 = 2.34.



## TEST # 33.

| TIME | GAUGE | CAL. 1 |                   | CAL. 2 | CAL. 3 |
|------|-------|--------|-------------------|--------|--------|
|      |       | TEMP.  | MAN<br>in.<br>HG. | TEMP.  | TEMP.  |
| 2:20 | 120   | 265    | .7                | 240    | 271    |
| 2:25 | 119.5 | 266    | .7                | 237    | 263    |
| 2:30 | 121   | 260    | .7                | 233    | 258    |
| 2:35 | 122   | 245    | .7                | 239    | 265    |
| 2:40 | 118   | 251    | .7                | 243    | 270    |

2 & 3 on same nipple, 1 on other.

Per cent moisture by 1 = 1.19

" " " " 2 = 1.97

" " " " 3 = .806

## TEST # 34.

| TIME | GAUGE | CAL. 1. |                    | CAL. 2 | CAL. 4. |                        |                        |
|------|-------|---------|--------------------|--------|---------|------------------------|------------------------|
|      |       | TEMP.   | MAN.<br>in.<br>HG. | TEMP.  | TIME    | STEAM<br>in<br>10 MIN. | WATER<br>in<br>10 MIN. |
| 3:20 | 118   | 250     | .7                 | 270    | 3:22    | 3.12                   | .013                   |
| 3:25 | 116   | 262     | .7                 | 271    |         |                        |                        |
| 3:30 | 119   | 257     | .7                 | 270    | 3:32    | 3.16                   | .062                   |
| 3:35 | 119   | 260     | .7                 | 267    |         |                        |                        |
| 3:40 | 120   | 261     | .7                 | 266    | 3:42    | 3.19                   | .131                   |

2 & 4 on same nipple, 3 on other.

Per cent moisture by 2 = 1.00

" " " " 3 = .616

" " " " 4 = 1.83



## TEST #35.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 3 |
|------|-------|--------|--------------------|--------|--------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TEMP.  |
| 3:50 | 125   | 286    | .5                 | 267    | 218    |
| 3:55 | 127.5 | 289    | .5                 | 272    | 218    |
| 4:00 | 128   | 290    | .5                 | 276    | 220    |
| 4:05 | 123.5 | 290    | .5                 | 273    | 225    |
| 4:10 | 117.5 | 288    | .5                 | 266    | 216    |
| 4:15 | 113.  | 287    | .5                 | 265    | 217    |
| 4:20 | 116   | 286    | .5                 | 266    | 216    |

1 & 3 on same nipple, 2 on open end nipple.

Percent moisture by 1 = .197.

" " " " 2 = .725.

" " " " 3 = 2.90.

## TEST #36.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 3 |
|------|-------|--------|--------------------|--------|--------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TEMP.  |
| 4:35 | 130   | 228    | .5                 | 230    | 259    |
| 4:40 | 126.5 | 238    | .5                 | 231    | 263    |
| 4:45 | 119   | 256    | .5                 | 234    | 258    |
| 4:50 | 118   | 260    | .5                 | 233    | 267    |
| 4:55 | 126   | 239    | .5                 | 233    | 259    |

1 & 2 on same nipple, 3 on open end nipple.

Percent moisture by 1 = 1.98

" " " " 2 = 2.56

" " " " 3 = .90



## TEST # 37.

|      |       | CAL. 1 |                    | CAL. 2 | CAL. 3 |
|------|-------|--------|--------------------|--------|--------|
| TIME | GAUGE | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.  | TEMP.  |
| 1:20 | 127   | 269    | .6                 | 255    | 270    |
| 1:25 | 125   | 272    | .6                 | 257    | 273    |
| 1:30 | 122   | 271    | .6                 | 261    | 270    |
| 1:35 | 124   | 275    | .6                 | 258    | 274    |
| 1:40 | 122   | 274    | .6                 | 263    | 278    |

2 & 3 on same nipple, 1 on other.

Per cent moisture by 1 = .55

" " " " 2 = 1.05

" " " " 3 = .50

## TEST # 38

|       |       | CAL. 1 |                    | CAL. 2 | CAL. 3. |
|-------|-------|--------|--------------------|--------|---------|
| TIME  | GAUGE | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.  | TEMP.   |
| 10:30 | 106.5 | 280    | .6                 | 246    | 270     |
| 10:35 | 111   | 279    | .6                 | 245    | 271     |
| 10:40 | 120   | 268    | .6                 | 214    | 258     |
| 10:45 | 117   | 276    | .6                 | 244    | 269     |
| 10:50 | 122   | 270    | .6                 | 233    | 262     |
| 10:55 | 110.5 | 276    | .6                 | 237    | 269     |
| 11:00 | 106   | 276    | .6                 | 240    | 267     |

1 & 2 on same nipple, 3 on open end nipple.

Per cent moisture by 1 = .264

" " " " 2 = 1.84

" " " " 3 = .665



## TEST # 39.

| TIME  | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 3 |
|-------|-------|--------|--------------------|--------|--------|
|       |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.  | TEMP.  |
| 11:10 | 103   | 268    | .6                 | 227    | 260    |
| 11:15 | 105   | 263    | .6                 | 216    | 258    |
| 11:20 | 107   | 271    | .6                 | 243    | 266    |
| 11:25 | 109   | 266    | .6                 | 228    | 262    |
| 11:30 | 109.5 | 265    | .6                 | 223    | 262    |
| 11:35 | 105   | 273    | .6                 | 263    | 273    |
| 11:40 | 102   | 278    | .6                 | 268    | 274    |

1 & 2 on same nipple, 3 on open end nipple.

Per cent moisture by 1 = .41.

" " " " 2 = 1.71.

" " " " 3 = .605.

## TEST # 40.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 3 |
|------|-------|--------|--------------------|--------|--------|
|      |       | TEMP.  | MAN.<br>IN.<br>HG. | TEMP.  | TEMP.  |
| 2:50 | 112   | 278    | .6                 | 258    | 269    |
| 2:55 | 118   | 282    | .6                 | 260    | 270    |
| 3:00 | 119   | 285    | .6                 | 262    | 270    |
| 3:05 | 118   | 284    | .6                 | 264    | 270    |
| 3:10 | 116   | 283    | .6                 | 266    | 270    |
| 3:15 | 114   | 282    | .6                 | 264    | 269    |
| 3:20 | 115   | 282    | .6                 | 264    | 269    |

1 & 2 on same nipple, 3 on open end nipple.

Per cent moisture by 1 = -.037

" " " " 2 = .685

" " " " 3 = .586



## TEST # 41.

| TIME | GAUGE | CAL. 1 |                    | CAL. 2 | CAL. 3 |
|------|-------|--------|--------------------|--------|--------|
|      |       | TEMP.  | MAN.<br>in.<br>HG. | TEMP.  | TEMP.  |
| 3:50 | 116   | 271    | .6                 | 268    | 288    |
| 3:55 | 116   | 275    | .6                 | 267    | 288    |
| 3:00 | 126   | 276    | .6                 | 266    | 289    |
| 4:05 | 118   | 269    | .6                 | 248    | 283    |
| 4:10 | 123   | 268    | .6                 | 246    | 283    |
| 4:15 | 124   | 268    | .6                 | 250    | 284    |
| 4:20 | 123   | 272    | .6                 | 255    | 286    |

2 & 3 on same nipple, 1 on open end nipple.

Per cent moisture by 1 = .59

" " " " 2 = 1.03

" " " " 3 = -.10



RESULTS OF TESTS  
with  
THREE CALORIMETERS ON SAME PIPE

| DATE<br>of<br>TEST                | PER-CENT MOISTURE BY CAL. N <sup>o</sup> . |       |        |       |
|-----------------------------------|--------------------------------------------|-------|--------|-------|
|                                   | 1.                                         | 2.    | 3.     | 4.    |
| 1 & 2 on same nipple, 4 on other. |                                            |       |        |       |
| 3/31                              | 0.945                                      | -0.15 |        | 0.60  |
| 1 & 4 on same nipple, 2 on other. |                                            |       |        |       |
| 3/31                              | 1.26                                       | 0.00  |        | 1.03  |
| 2 & 4 on same nipple, 1 on other. |                                            |       |        |       |
| 3/31                              | 1.43                                       | 0.00  |        | 1.89  |
| 1 & 3 on same nipple, 4 on other. |                                            |       |        |       |
| 4/3                               | 2.50                                       |       | 1.97   | 0.60  |
| 1 & 2 on same nipple, 4 on other. |                                            |       |        |       |
| 4/3                               | 1.705                                      | 2.88  |        | 1.90  |
| 1 & 3 on same nipple, 4 on other. |                                            |       |        |       |
| 4/5                               | 0.152                                      |       | 1.92   | 1.27  |
| 3 & 4 on same nipple, 1 on other. |                                            |       |        |       |
| 4/5                               | 0.276                                      |       | 1.36   | 1.68  |
| 1 & 4 on same nipple, 2 on other. |                                            |       |        |       |
| 4/6                               | 0.247                                      | 1.21  |        | 0.97  |
| 2 & 4 on same nipple, 3 on other. |                                            |       |        |       |
| 4/6                               |                                            | 0.845 | 0.57   | 0.780 |
| 3 & 4 on same nipple, 2 on other. |                                            |       |        |       |
| 4/6                               |                                            | 0.56  | 0.316  | 0.89  |
| 2 & 3 on same nipple, 1 on other. |                                            |       |        |       |
| 4/10                              | 0.698                                      | 0.167 | 1.99   |       |
| 2 & 3 on same nipple, 1 on other. |                                            |       |        |       |
| 4/10                              | 1.39                                       | 2.07  | -0.395 |       |



| DATE<br>of<br>TEST                         | PER-CENT MOISTURE BY CAL. No |        |       |       |
|--------------------------------------------|------------------------------|--------|-------|-------|
|                                            | 1                            | 2      | 3     | 4     |
| 2 & 4 on same nipple, 1 on other.          |                              |        |       |       |
| 4/17                                       | 3.19                         | 3.10   |       | 1.94. |
| 1 & 2 on same nipple, 4 on other.          |                              |        |       |       |
| 4/17                                       | 0.558                        | -0.148 |       | 4.70  |
| 1 & 2 on same nipple, 4 on slotted nipple. |                              |        |       |       |
| 4/18                                       | 0.70                         | 0.57   |       | 2.40  |
| 1 & 2 on same nipple, 4 on slotted nipple. |                              |        |       |       |
| 4/18                                       | 0.54                         | -0.105 |       | 0.116 |
| 1 & 2 on same nipple, 4 on slotted nipple. |                              |        |       |       |
| 4/18                                       | 0.30                         | 0.696  |       | 0.193 |
| 1 & 2 on same nipple, 4 on slotted nipple  |                              |        |       |       |
| 4/18                                       | 0.114                        | -0.173 |       | 0.031 |
| 1 & 4 on same nipple, 3 on other.          |                              |        |       |       |
| 4/19                                       | 1.77                         |        | 1.36  | 1.64  |
| 3 & 4 on same nipple, 1 on other.          |                              |        |       |       |
| 4/19                                       | 0.50                         |        | 1.75  | 6.90  |
| 1 & 3 on same nipple, 2 on other.          |                              |        |       |       |
| 4/20                                       | 2.57                         | 1.81   | 2.14  |       |
| 2 & 4 on same nipple, 3 on other.          |                              |        |       |       |
| 4/20                                       |                              | 1.55   | 1.13  | 1.46. |
| 1 & 2 on same nipple, 3 on slotted nipple  |                              |        |       |       |
| 4/24                                       | 0.30                         | -0.90  | 0.156 |       |
| 1 & 2 on same nipple, 3 on slotted nipple. |                              |        |       |       |
| 4/24                                       | -0.20                        | 0.735  | 0.30  |       |
| 1 & 2 on same nipple, 3 on slotted nipple. |                              |        |       |       |
| 4/24                                       | 0.30                         | 0.753  | 0.355 |       |



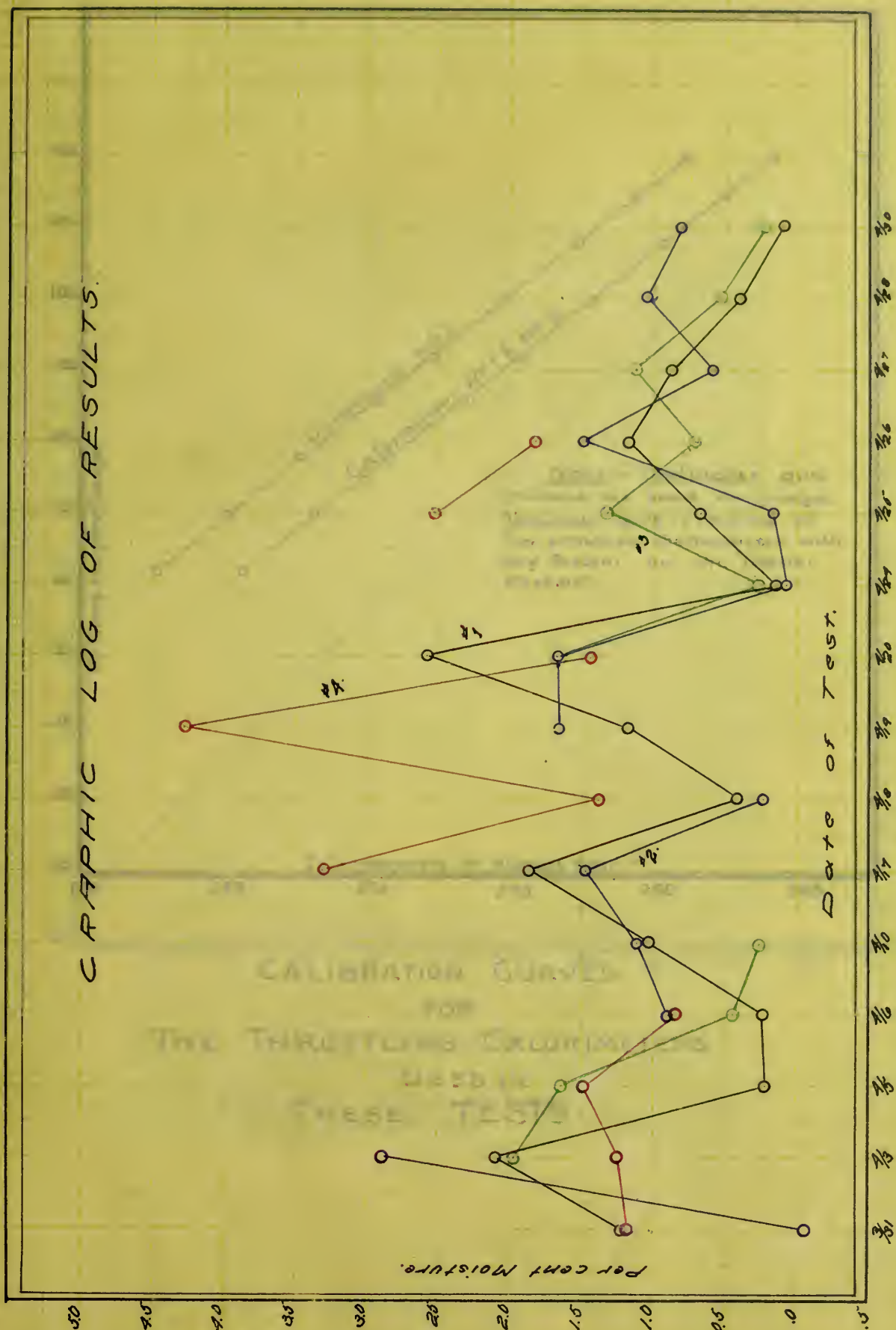
| DATE<br>of<br>TEST                          | PER-CENT MOISTURE BY CAL. N° |       |       |      |
|---------------------------------------------|------------------------------|-------|-------|------|
|                                             | 1                            | 2     | 3     | 4    |
| 1 & 2 on same nipple, 3 on slotted nipple.  |                              |       |       |      |
| 4/24                                        | 0.30                         | 0.723 | 0.24  |      |
| 1 & 4 on same nipple, 3 on other.           |                              |       |       |      |
| 4/25                                        | 0.68                         |       | 1.09  | 2.72 |
| 3 & 4 on same nipple, 2 on other.           |                              |       |       |      |
| 4/25                                        |                              | 0.271 | 1.57  | 2.34 |
| 2 & 4 on same nipple, 3 on other.           |                              |       |       |      |
| 4/26                                        |                              | 1.00  | 0.616 | 1.83 |
| 2 & 3 on same nipple, 1 on other.           |                              |       |       |      |
| 4/26                                        | 1.19                         | 1.97  | 0.806 |      |
| 1 & 3 on same nipple, 2 on other.           |                              |       |       |      |
| 4/27                                        | -0.197                       | 0.290 | 0.725 |      |
| 1 & 2 on same nipple, 3 on other.           |                              |       |       |      |
| 4/27                                        | 1.98                         | 0.90  | 2.56  |      |
| 1 & 2 on same nipple, 3 on other.           |                              |       |       |      |
| 4/28                                        | 0.264                        | 0.455 | 0.665 |      |
| 1 & 2 on same nipple, 3 on open end nipple  |                              |       |       |      |
| 4/28                                        | 0.41                         | 1.71  | .605  |      |
| 1 & 2 on same nipple, 3 on open end nipple. |                              |       |       |      |
| 4/28                                        | 0.55                         | 1.05  | 0.50  |      |
| 2 & 3 on same nipple, 1 on other.           |                              |       |       |      |
| 4/30                                        | 0.59                         | 1.03  | -0.10 |      |
| 1 & 2 on same nipple, 3 on other.           |                              |       |       |      |
| 4/30                                        | -0.37                        | 0.685 | 0.585 |      |



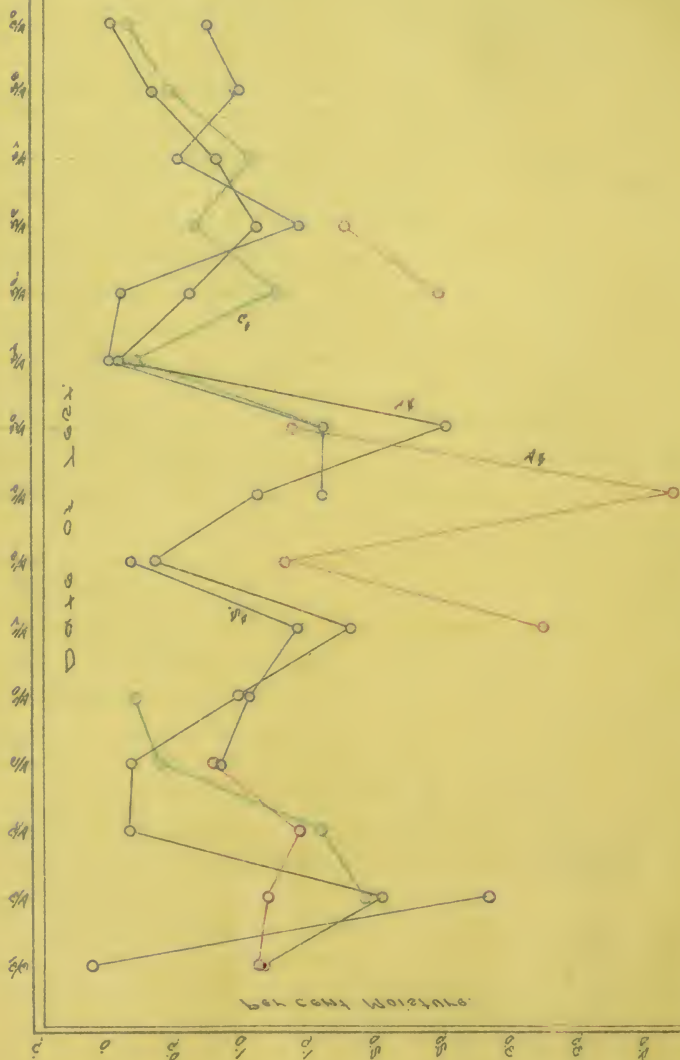
# COMPARISON OF TWO CALORIMETERS ON SAME NIPPLE

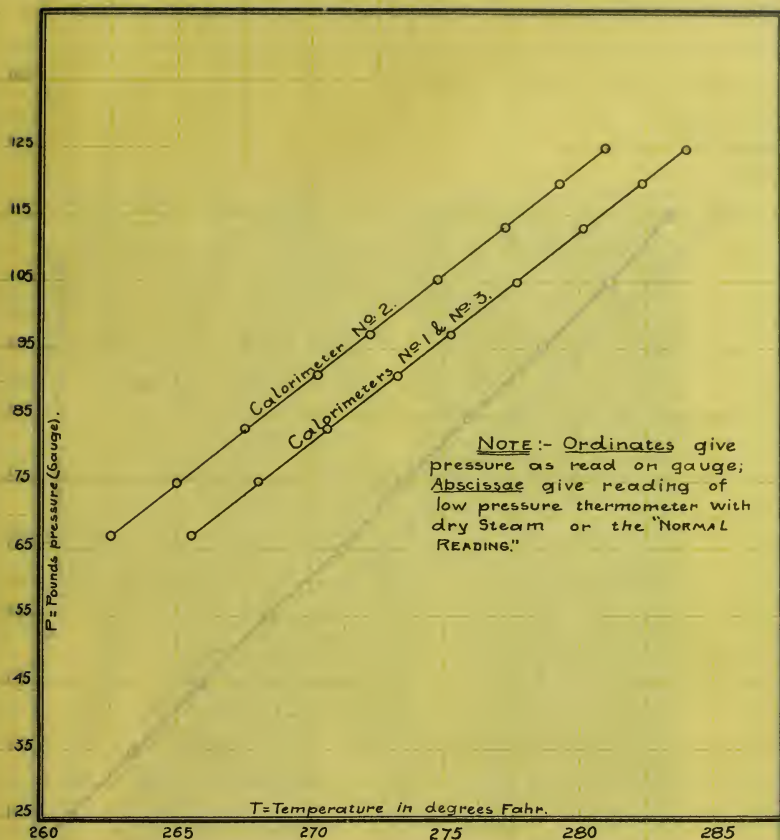
| DATE<br>or<br>TEST | PER-CENT MOISTURE BY CALORIMETER NO |        |        |       |       |      |       |        |       |      |      |      |
|--------------------|-------------------------------------|--------|--------|-------|-------|------|-------|--------|-------|------|------|------|
|                    | 1                                   | 2      | 1      | 3     | 1     | 4    | 2     | 3      | 2     | 4    | 3    | 4    |
| 3/31               | 0.945                               | -0.15  |        |       | 1.26  | 1.03 |       |        | 0.00  | 1.85 |      |      |
| 4/3                | 1.705                               | 2.88   | 2.50   | 1.97  |       |      |       |        |       |      |      |      |
| 4/5                |                                     |        | 0.152  | 1.92  |       |      |       |        |       |      | 1.36 | 1.68 |
| 4/6                |                                     |        |        |       |       |      | 2.76  | 1.60   |       |      | 2.19 | 0.50 |
| 4/7                |                                     |        |        |       | 0.247 | 0.97 |       |        | 0.845 | 0.78 | 0.30 | 0.89 |
| 4/10               |                                     |        | 1.88   | 1.93  |       |      | 0.167 | 1.99   |       |      |      |      |
| 4/10               |                                     |        |        |       |       |      | 0.27  | -0.395 |       |      |      |      |
| 4/17               | 0.558                               | -0.198 |        |       |       |      |       |        | 3.10  | 1.99 |      |      |
| 4/18               | 0.170                               | 0.057  |        |       |       |      |       |        |       |      |      |      |
| 4/18               | 1.054                               | -0.105 |        |       |       |      |       |        |       |      |      |      |
| 4/18               | 0.300                               | 0.696  |        |       |       |      |       |        |       |      |      |      |
| 4/18               | 0.114                               | -0.113 |        |       |       |      |       |        |       |      |      |      |
| 4/19               |                                     |        |        |       | 1.77  | 1.67 |       |        |       |      | 1.75 | 6.90 |
| 4/20               |                                     |        | 2.57   | 2.14  |       |      |       |        | 1.55  | 1.46 |      |      |
| 4/23               | 0.549                               | 0.002  |        |       |       |      |       |        |       |      |      |      |
| 4/24               | 0.30                                | -0.96  |        |       |       |      |       |        |       |      |      |      |
| 4/24               | -0.20                               | 0.235  |        |       |       |      |       |        |       |      |      |      |
| 4/24               | 0.30                                | 0.753  |        |       |       |      |       |        |       |      |      |      |
| 4/24               | 0.30                                | 0.723  |        |       |       |      |       |        |       |      |      |      |
| 4/25               |                                     |        |        |       | 0.68  | 2.72 |       |        | 1.57  | 2.34 |      |      |
| 4/26               |                                     |        |        |       |       |      | 1.97  | 0.806  |       |      | 1.00 | 1.83 |
| 4/27               | 1.98                                | 0.90   | -0.197 | 0.725 |       |      |       |        |       |      |      |      |
| 4/28               | 0.269                               | 0.455  |        |       |       |      |       |        |       |      |      |      |
| 4/28               | 0.41                                | 1.71   |        |       |       |      |       |        |       |      |      |      |
| 4/30               | -0.37                               | 0.685  |        |       |       |      |       |        |       |      |      |      |
| 4/30               |                                     |        |        |       |       |      | 1.03  | -1.00  |       |      |      |      |





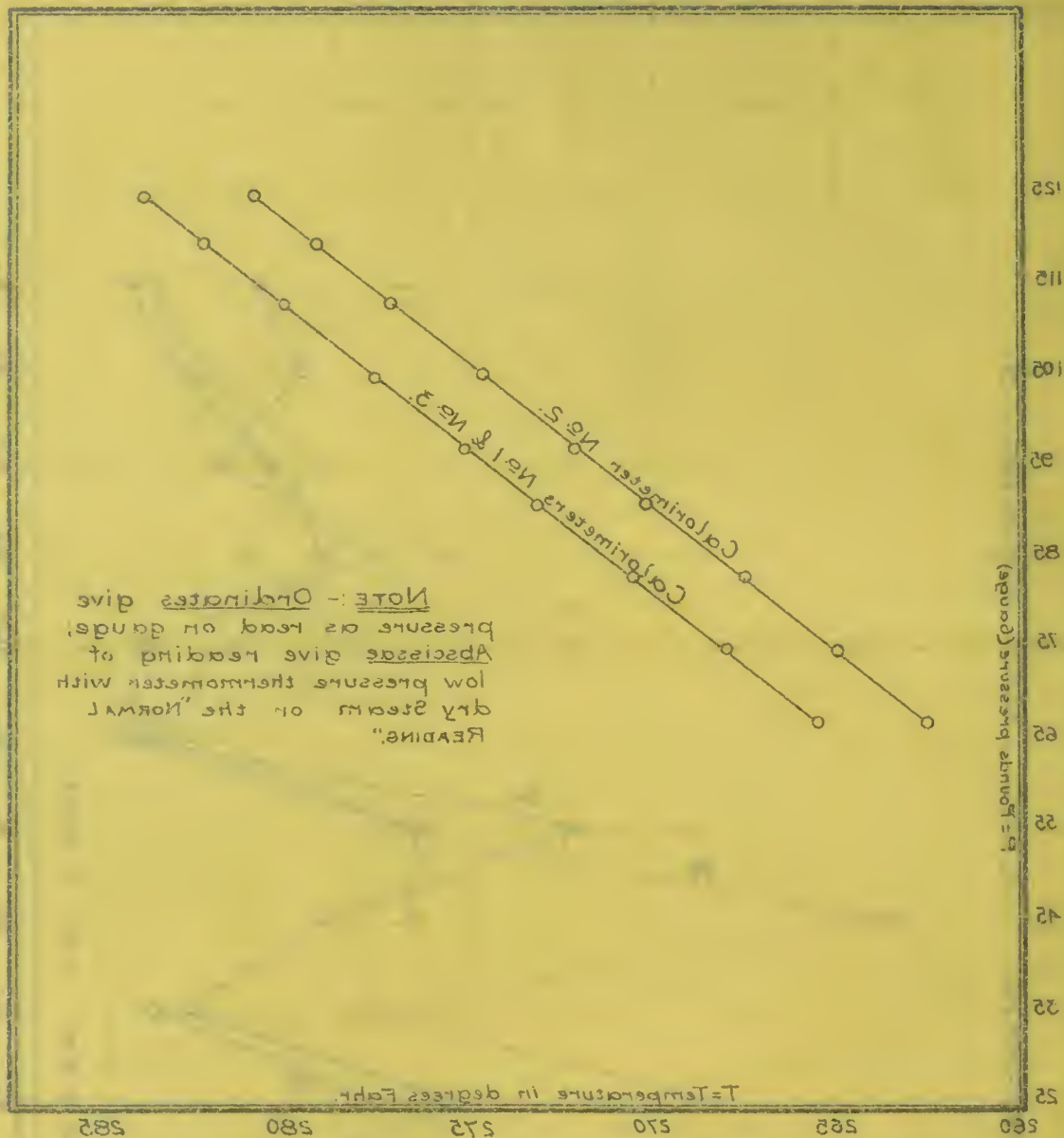
# STANDARD FOR SOLUBLE

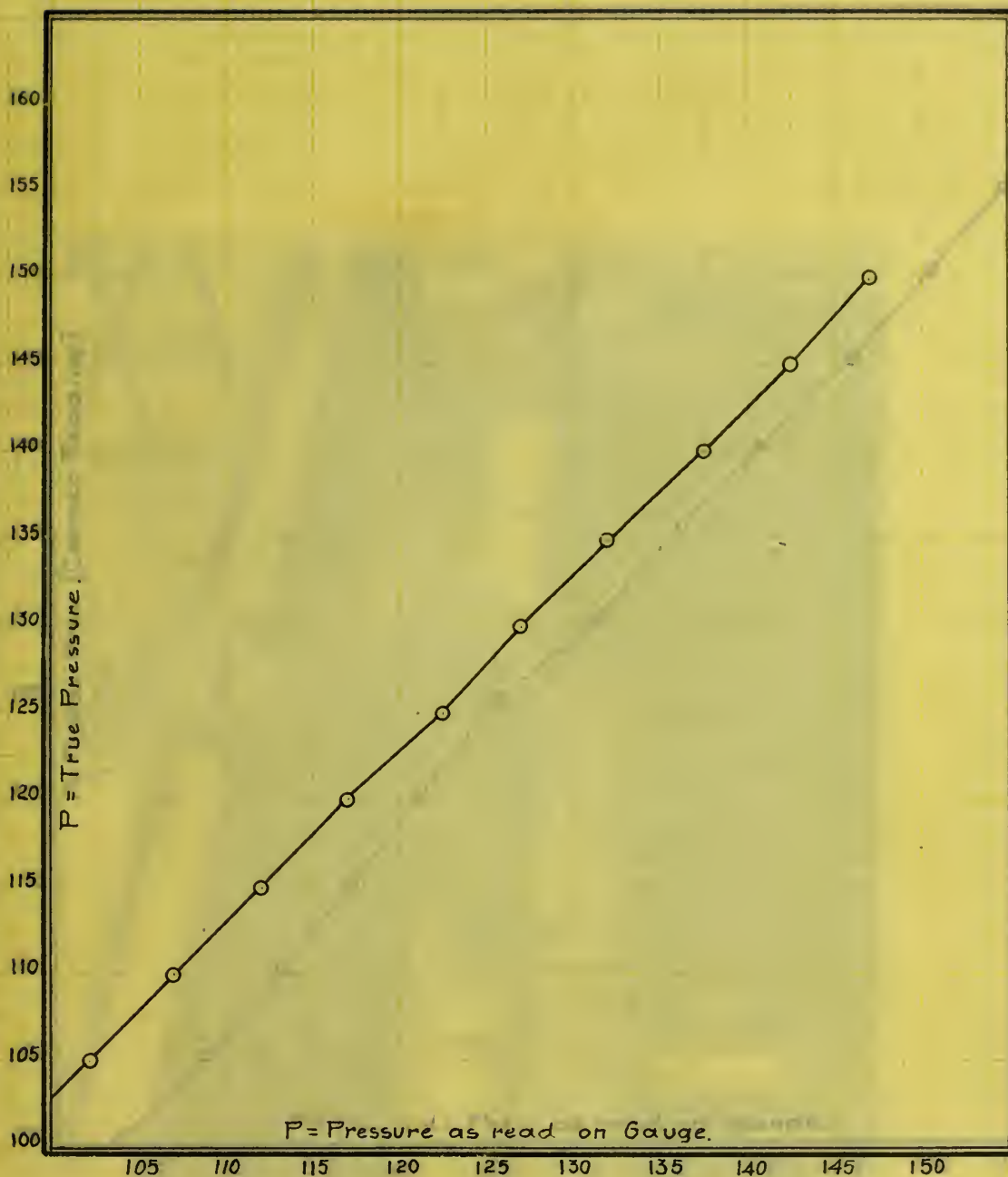




CALIBRATION CURVES  
FOR  
THE THROTTLING CALORIMETERS  
USED IN  
THESE TESTS

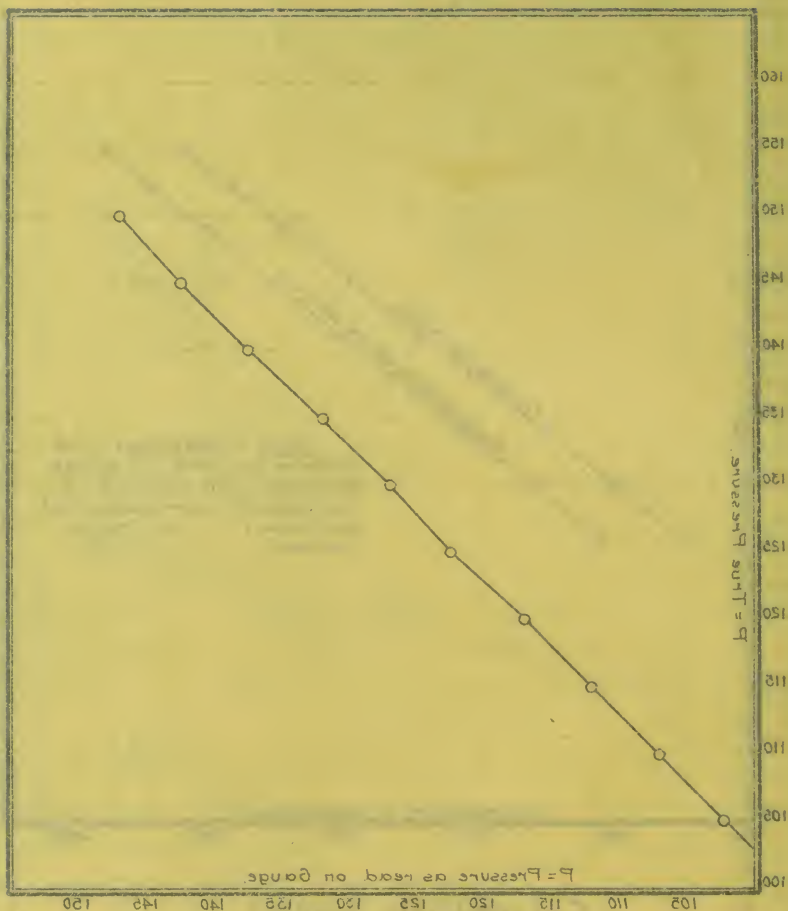
# THESE TESTS USED IN THE THROTTLING CALORIMETERS FOR CALIBRATION CURVES

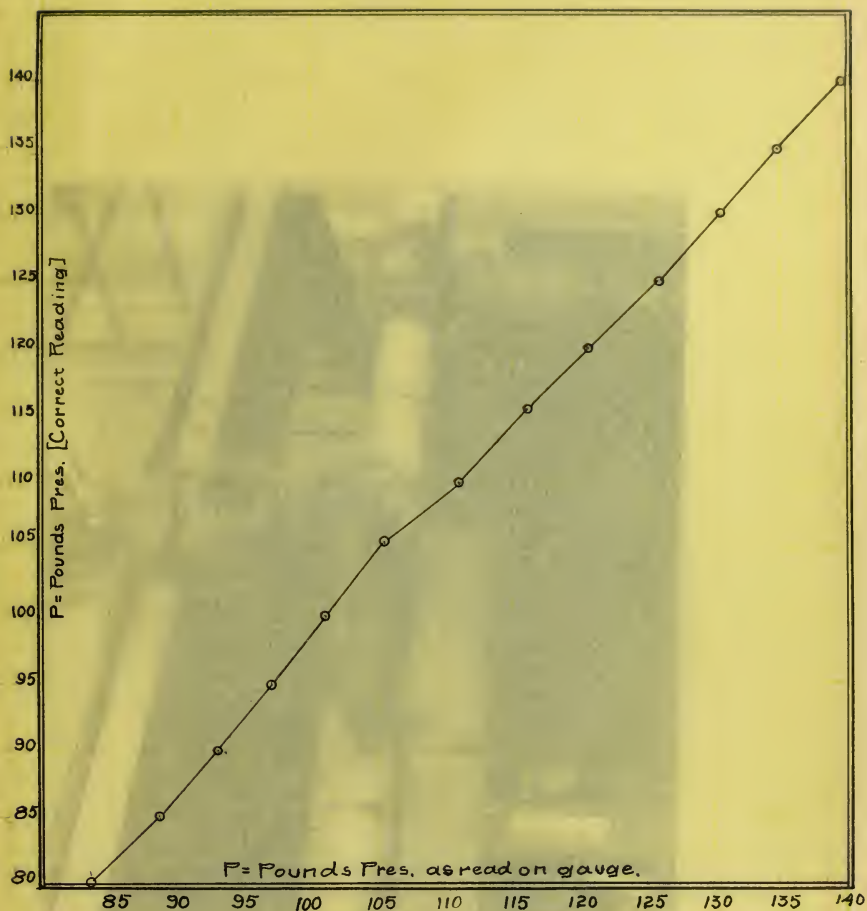




CALIBRATION  
FOR  
CROSBY STEAM-GAUGE  
[No. 520105].

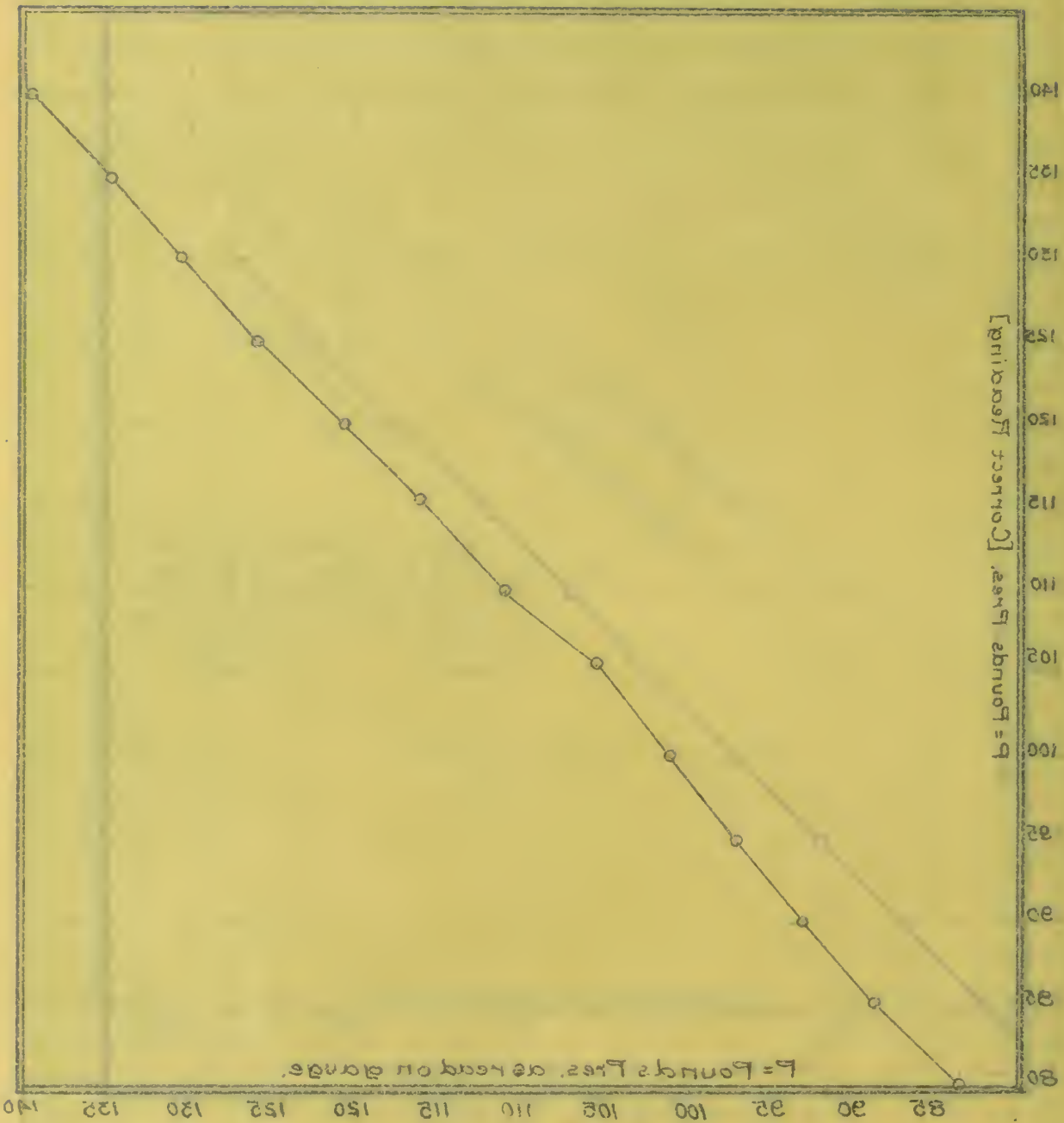
CROSBY STEAM-GAUGE  
[No. 250102]  
FOR  
CALIBRATION

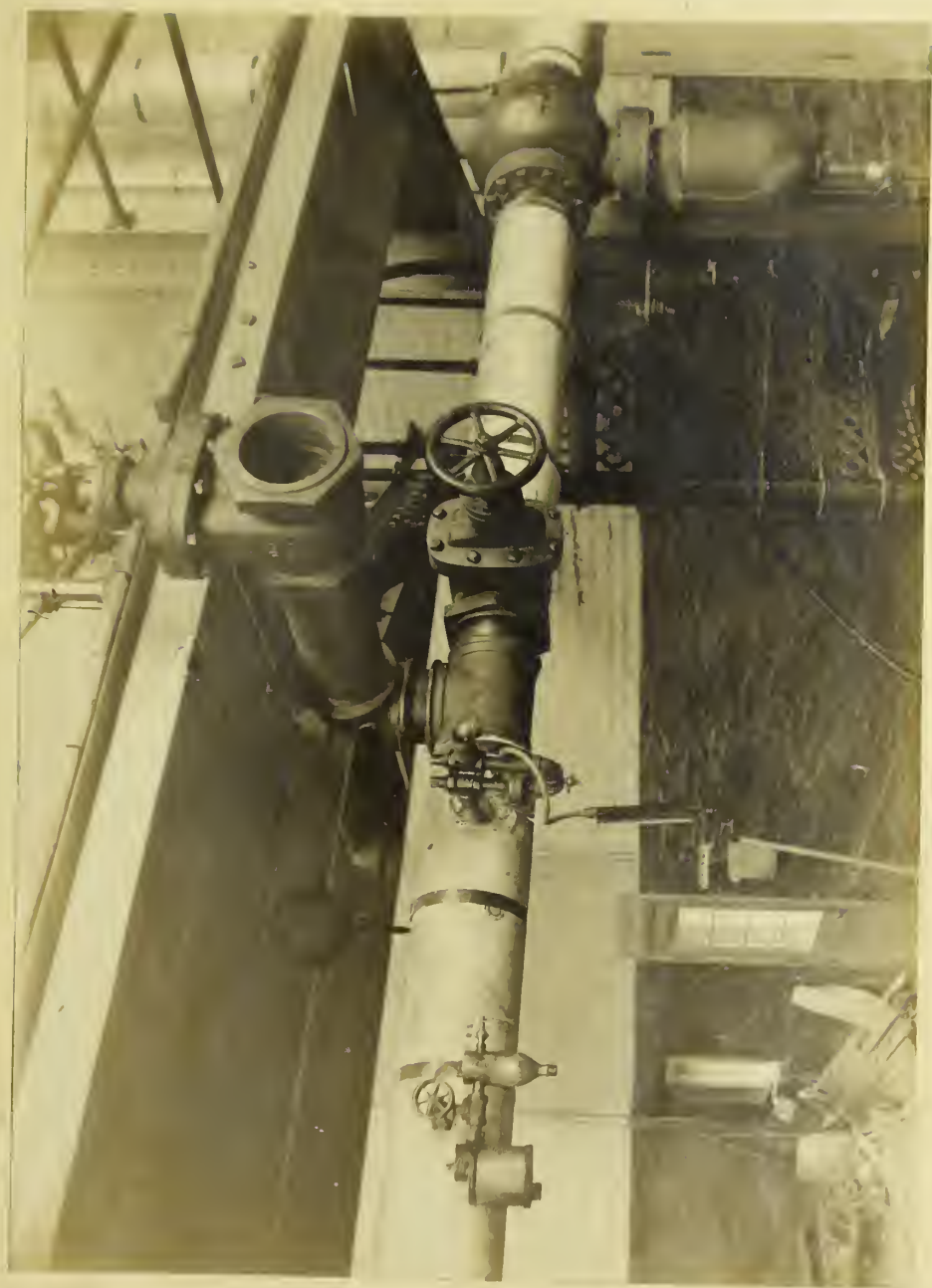




CALIBRATION CURVE  
FOR  
SCHAEFFER & BUDENBURG  
STEAM-GAUGE  
NO 1803005.

STEAM-GAUGE  
 SCHAEFFER & BUDENBURG  
 FOR  
 CALIBRATION CURVE  
 No. 1803002







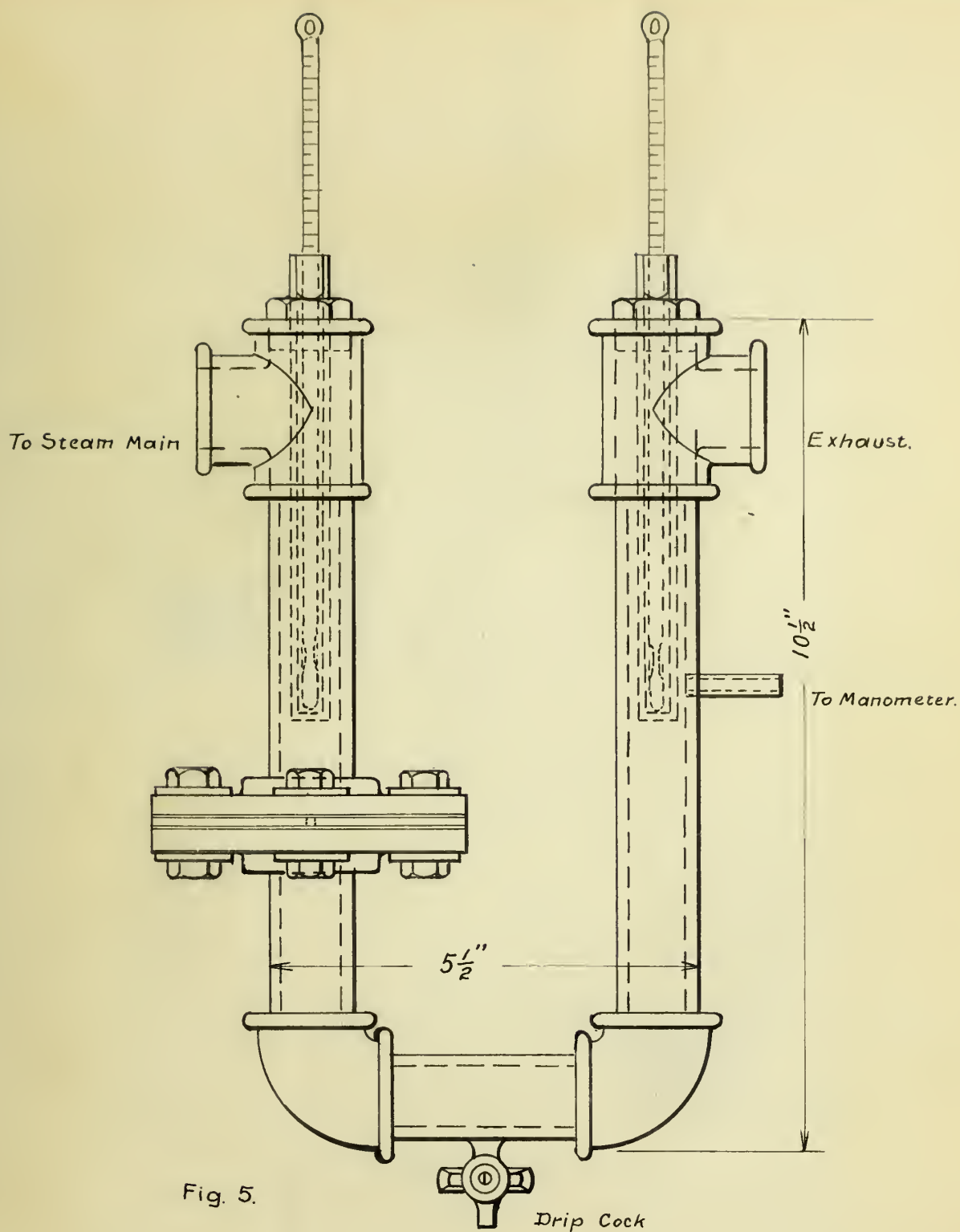


Fig. 5.

THROTTLING CALORIMETER  
Made of  
 $\frac{3}{4}"$  PIPE FITTINGS.



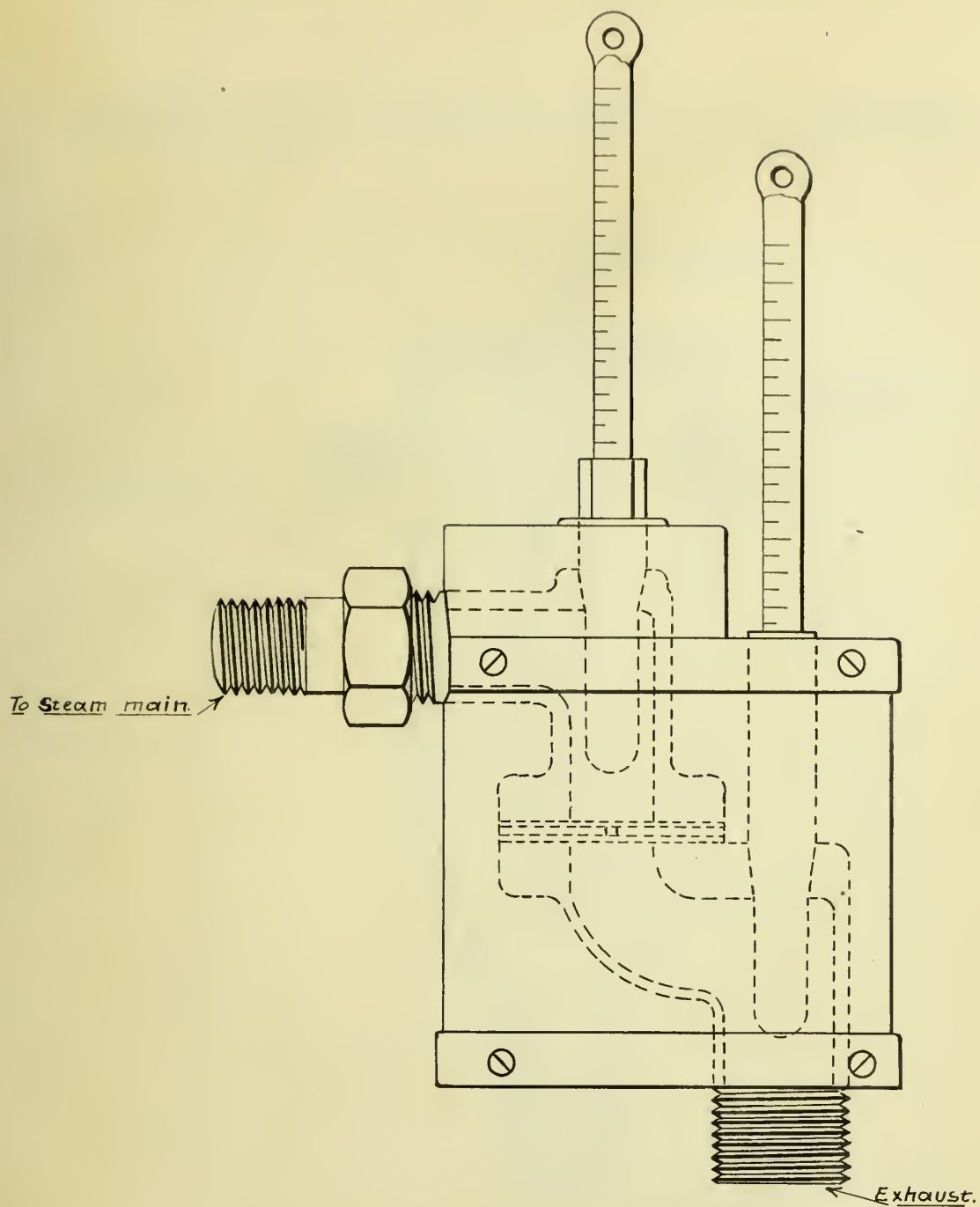


Fig. 6.

UNIVERSAL CALORIMETER.  
[1895 PATTERN]



# CARPENTER'S THROTTLING CALORIMETER.

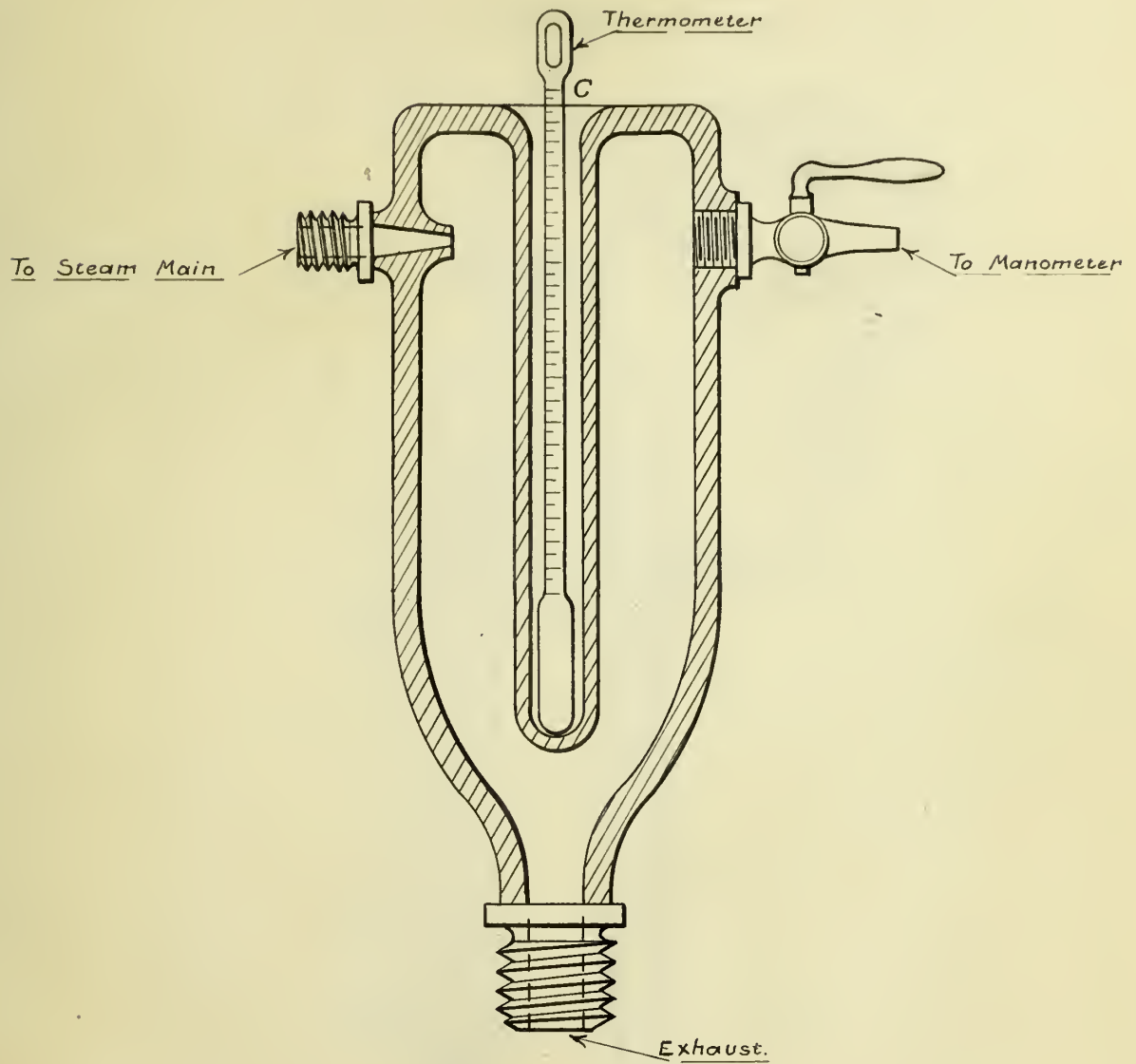


Fig. 7.



## CARPENTER'S SEPARATING CALORIMETER.

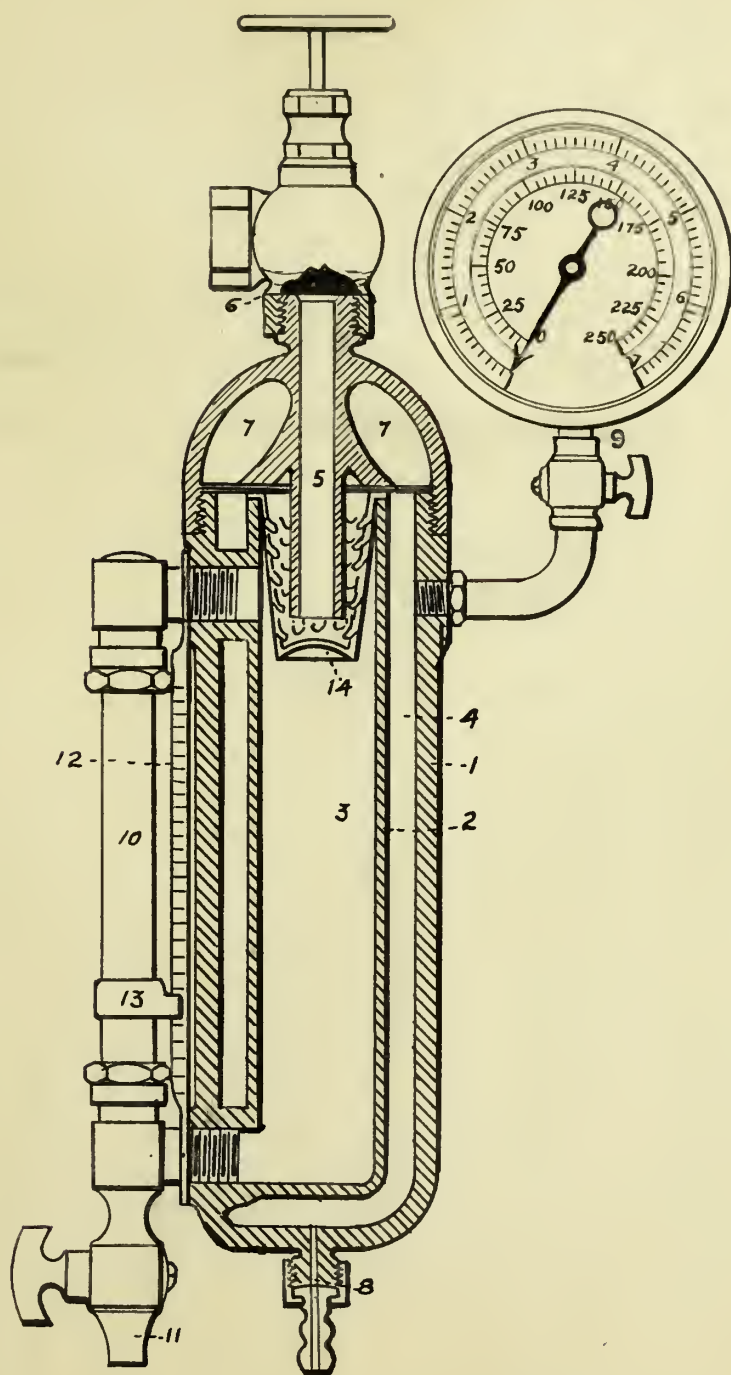


Fig. 8.



## CONCLUSIONS.

We have included in this thesis all the data taken. This was done for two reasons: First, in order to show clearly the results of the tests; Second, in order to show the variation in simultaneous readings of the thermometers in different calorimeters.

The table on page (41) shows the variation in readings of two calorimeters on the same nipple. This variation in the per cent of moisture as indicated by two calorimeters on the same nipple is seen to have ranged from .001 per cent to 5.15 per cent. Knowing the care with which all readings were taken we see no excuse for this discrepancy except simple unreliability of the instruments. It is upon these tests that we base our conclusions in regard to throttling calorimeters since in the other tests the discrepancy might be due to difference in the samples.

Others have maintained, and gone to some length to account for the fact that the error in the reading of throttling calorimeters is always an exaggeration of the amount of moisture. Our observations, however, lead us to believe that the throttling calorimeter may either exaggerate or underrate the true amount of moisture. We shall attempt no explanation for the failure of this instrument, other than the fact that it is one of those cases where theory and practice do not agree.

The tests with different forms of nipples were made in order to determine whether or not the nipple has any effect upon the sample obtained. Since our tests show that the throttling



calorimeter cannot be depended upon, we used only the readings of the separating calorimeter in drawing any conclusions in regard to the effect of the form of nipple. We found that in the case of the slotted nipple the position of the slot with respect to the direction of the current of steam in the main has a decided effect upon the sample obtained. With the slot turned towards or away from the current the amount of moisture was considerably greater than when the slot was at right angles to the current. The sample obtained by an open-end nipple seems to contain more moisture than that obtained by the perforated nipple.

At all events it is certain that the quality of the sample taken depends largely upon the form of nipple used. It is generally agreed that the ordinary perforated nipple gives the fairest sample and we are in no position to dispute this view.

In view of these forty-four tests which we have made we feel perfectly warranted in saying that the throttling calorimeter is not to be depended upon. We have actually seen water dripping from an instrument while the lower thermometer indicated superheat.

We do believe, however, that the separating calorimeter is fairly accurate when the steam is not too wet and is at least not liable to any such radical errors as is the throttling type.





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